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SOME NEW VIEW POINTS IN NUTRITION[1]

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IN the latter part of the seventeenth century, long prior to the discovery of oxygen, the English chemist, John Mayow, had laid hold of the important principle that there is something in the air necessary for combustion; that this something is capable of exerting its influence whether it exists free in the air or is combined in the substance undergoing combustion. Further, he pointed out that in the processes of burning and breathing there is a certain definite relationship in that both consist in the consumption of the so-called igneo-aerial particles of the air. He made clear by experiment that the views then prevailing regarding respiration, in which it was held that breathing serves to cool the heat of the heart or to facilitate the passage of the blood from the right to the left side of the heart were quite erroneous. He maintained that in breathing, something belonging to the air, something essential for sustaining life passes from the air into the blood. To quote from his own statement:[2] "On the one hand it clearly appears that animals exhaust the air of certain vital particles which are of an elastic nature. On the other hand there can not be the slightest doubt but that some constituent of the air absolutely necessary to life enters into the blood in the act of breathing."

We fully understand to-day that Mayow's igneo-aerial particles were what we call oxygen, and that in some mysterious fashion he had

[1] An address before the Sigma Xi societies of the universities of Missouri, Kansas, Nebraska, Iowa and Minnesota, February, 1908.

[2] Taken from Sir Michael Foster's "Lectures on the History of Physiology during the Sixteenth, Seventeenth and Eighteenth Centuries," Cambridge University Press, 1901, p. 194.

arrived at a fairly accurate conception of the important part played by these particles in the processes of life. He recognized that the substance embodied in these particles "formed only a part of the atmosphere, that it was essential for burning, that it was essential for all the chemical changes on which life depends, that it was absorbed into the blood from the lungs, carried by the blood to the tissues, and in the tissues was the pivot, the essential factor of the chemical changes by which the vital activities of this or that tissue are manifested. It was essential in muscle to the occurrence of muscular contractions, it was essential in the brain to the development of animal spirits. This great truth was reached at a time when the men of chemistry were struggling with the spiritualistic fermentations of van Helmont on the one hand, and with the material effervescences of Sylvius on the other. It was reached by a young man of twenty-five years, who died a few years afterwards."[3]

For nearly a hundred years this fundamental idea so skillfully worked out lay practically dormant and no material progress was made until, in the latter part of the eighteenth century, Priestley prepared his dephlogisticated air and Lavoisier discovered oxygen. Then came essentially a revival of Mayow's views concerning respiration, only with a clearer understanding of the nature of the process. As stated by Lavoisier and Laplace, "respiration is a combustion, slow it is true, but otherwise perfectly similar to the combustion of charcoal. It takes place in the interior of the lung without giving rise to sensible light because the matter of the fire (the caloric) as soon as it is set free, is forthwith absorbed by the humidity of these organs. The heat developed by this combustion is communicated to the blood which is traversing the lungs and from the lungs is distributed over the whole animal system."[4]

In this conception of so-called respiration the fundamental errors as viewed from the standpoint of to-day are first: the idea that the process deals solely with the combustion of carbon and secondly, that the process is limited to the lungs where a hydrocarbonous fluid was supposed to be secreted, *i. e.*, from or through the tubes of the lungs. Later, Lavoisier himself recognized that in this process of combustion in the animal body hydrogen (discovered by Cavendish in 1781) was likewise involved, and that water as well as carbon dioxide was a normal product of the oxidation that is associated with respiration. Still later, the Italian investigator, Spallanzani, through his experiments on animals broadened the conceptions then prevailing by proving that the individual tissues of the body, like the organism as a whole, respire, *i. e.*, that they consume oxygen and produce carbon dioxide. This

[3] Quoted from Sir Michael Foster, *loc. cit.*, p. 198.

[4] *Ibid.*, p. 249.

view, however, was slow in gaining ground, and for years it was generally held that oxidation as it occurs in the animal body takes place mainly in the lungs. Not until 1837 when Magnus, through use of the air pump, showed conclusively that both arterial and venous blood contain the two gases oxygen and carbon dioxide, though in different proportions, did the theory of respiration and its connection with oxidation take on its present form. Then, gradually, physiologists began to perceive that pulmonary or external respiration had to do primarily with the exchange of gaseous materials and that oxidation did not occur in the lungs, neither to any degree in the circulating blood, but rather in the different tissues and organs of the body where activity of various sorts prevails.

The processes of life, the processes of nutrition, soon came to be looked upon as essentially processes of oxidation. The work of Lavoisier in 1780, indicating as it did that animal heat is the result of a process of slow combustion in which oxygen is used up and carbon dioxide produced, a process analogous to that of the burning candle, naturally emphasized the idea of oxidation. As to the nature of the substance or substances undergoing combustion in the animal body, knowledge at that time was somewhat vague and indefinite. Later, when Chevreul had made his classical studies of fats and Mulder had essayed a description of protein, Liebig came forward with his theories of nutrition, among which was the view so long upheld, that the fats and carbohydrates of the food are burned up directly by the inspired oxygen, while the protein is used to replace the protein of the tissues, the latter being oxidized to furnish energy for muscle work. Liebig conceived that oxygen was the *cause* of oxidation, a view shown to be incorrect by the well-established fact that animals produce no more carbon dioxide in an atmosphere rich in oxygen than under ordinary atmospheric conditions, *i. e.*, unlike the processes of combustion outside the organism a forced draft is without effect on the rate of burning. Moreover, it was found that oxidation would take place in a tissue independent of an intake of free oxygen, viz., that a contracting muscle, for example, would give out carbon dioxide even when made to contract in a vacuum, thus implying a decomposition or disassociation in which combined oxygen must have been made use of. Further, it was evident that in the tissues and organs of the body, oxidation proceeded gradually through a series of successive steps; the large, complex molecules of the food and tissues being slowly transformed into simpler molecules with ultimate formation of carbon dioxide and water, plus some nitrogen-containing compounds of a relatively simple nature.

During all these years, since the time of Mayow and the later discovery of oxygen, oxidation has been the key-note to which all the varied changes characteristic of life have been adjusted. In ultimate

analysis, the breaking down of tissue material in the complicated processes of catabolism has been ascribed to oxidation. While this explanation is in a measure true, the passing years have brought to light many additional data which tend to show that simple oxidation is quite inadequate to account for the variety of transformations that pertain to nutrition. Many other factors are involved that give to these processes a totally different and at the same time broader scope than was formerly thought of. The simple views of Lavoisier and the later theories of Liebig do not suffice; they fail to explain the numerous and complicated reactions occurring during life.

Something was lacking in our knowledge during these earlier years, and that was an understanding of the rôle of the cell in nutrition. It was difficult for the chemists of this period to let go of the tempting hypothesis that oxidation in the animal body was akin to that of ordinary combustion and their eyes were apparently closed to the many inconsistencies that such a theory imposed. When, however, Virchow developed his cellular hypothesis and it became clear that the living cell was the morphological unit of the body, then it gradually dawned on the physiological world that the cell was likewise the seat of the many chemical transformations associated with nutrition. Oxidation could not occur in the lungs, it did not take place in the blood, there was no one particular spot where the fires of the body were located. On the contrary, they occurred everywhere, in every living cell, and all kinds of combustible or oxidizable material were burned. This conception, in which the living cells might well be compared to miniature laboratories, is now thoroughly justified by the facts at our disposal. Still, it is not the cell as a physiological unit that is to be considered as the cause of the varied decompositions that occur in the body. Enzymes of various types appear in the foreground whenever we attempt to unravel the nature of the processes associated with nutrition; and this is equally true whether we are dealing with the changes incidental to digestion or with those more subtle ones associated with the processes of metabolism. In the living cells of the body there are many agencies at command, enzymes or ferments of divergent forms endowed with the power of inciting and carrying forward chemical changes of differing degrees of magnitude, by means of which complex organic matter is made to undergo alteration and decomposition.

Turn for a time to the changes which the protein or albuminous foods undergo in digestion. Here we have what was for a long period considered as a simple process of transformation or polymerization, brought about mainly through the agency of the two enzymes pepsin and trypsin, of the gastric and pancreatic juice, respectively. Physiologists for years believed they understood the purport of this process, which was merely to transform the protein foods into soluble and more

or less diffusible modifications adapted for absorption into the circulating blood. The various forms of vegetable and animal proteins supposedly underwent transmutation without much chemical change, into closely allied substances which by simple osmosis or diffusion could enter the circulation and thus be distributed throughout the body. We see in these views a striking example of how preconceived ideas stand in the way of progress. Advance of knowledge is frequently held back by our proneness to interpret observations or data in harmony with our conception of what they should signify. The old-time physiologists knew full well that the protein of the blood and tissues was made good by the protein of the food, and digestion as they understood it was adequate for the purpose, viz., to transform the protein into a soluble and diffusible form. Anything beyond this was not only unnecessary, but uneconomical and wasteful. I well remember an experience of my own twenty-five years ago in Germany when I was at work on the so-called primary and secondary proteoses formed in gastric digestion, substances at that time just discovered as products of digestive action; how an eminent physiologist from Dorpat happened in the laboratory one day, and after looking at some of the products he turned to Kühne, who was standing near-by and remarked, "It is certainly interesting to see what changes pepsin is capable of producing, but of course they have little bearing on the processes that take place in the stomach and intestine, where naturally the sole aim is to fit protein for absorption."

Another eminent physiologist, whose name has long been known to every student of the science, remarked once in my hearing that the acid-albumin stage, the first product formed by pepsin-acid, was as far as gastric digestion need extend, since this substance was easily absorbed and it was a useless waste of energy for protein to undergo conversion into primary and secondary proteoses and peptone. I recall also what controversies arose when it was established that artificial pancreatic juice could break down protein into leucine and tyrosine; those two crystalline amino-acids now so well known as decomposition products of most proteins. When the fact was established beyond a shadow of doubt, physiologists were still disinclined to believe that any appreciable amount of these relatively simple substances could be formed in ordinary digestion, because such a view was so strongly opposed to the general purpose of protein digestion as then held. We were not inclined to follow the path which experiment was opening up simply because our eyes were blinded by preconceived ideas. I recall an early experiment made by Kühne and myself in the Heidelberg laboratory where a dog was fed a large amount of meat and then after a suitable time chloroformed, the small intestine ligatured and the contents analyzed. We found a gram or more of leucine and tyrosine, which we weighed and identified, thus proving to our satisfaction at least that these two

amino-acids were formed in ordinary intestinal digestion. But such data twenty-five years ago, and indeed up to very recent times, failed to attract much attention or were misinterpreted. Physiologists hastened to formulate a theory which would harmonize with existing views, and so arose the theory of "luxus consumption," in which it was held that when an excess of protein food was taken, far larger than the demands of the body called for, the organism was able to protect itself by virtue of this power possessed by trypsin of breaking down protein matter into simple decomposition products easily got rid of with less strain upon liver, kidneys and other organs and tissues.

Many of you doubtless remember the experiments of Schmidt-Mülheim and of Fano, who attempted to determine the amounts of proteoses and peptones present in the blood of dogs after a hearty meal of protein food; and how the negative results they obtained led finally to experiments on the injection of these substances directly into the blood, in which it was found that marked physiological action followed. In other words, proteoses and peptones are not normal constituents of the blood, even though there be a large amount of them in the intestine. They are plainly not absorbed as such, and this fact led to the theory—apparently supported by experiment—that proteoses and peptones in the very act of absorption, in their passage through the epithelial cells of the intestinal wall, are transformed into the proteins of the blood. This made a convenient way of explaining the facts, and one could well imagine that the system took this method of reinforcing the proteins of blood, lymph and tissue. Data, however, have been slowly accumulating which do not admit of such easy interpretation. Physiological chemists interested in enzyme action and equally interested in the chemical constitution of protein matter have been gradually collecting evidence of much significance. A row of diamino-acids, arginine, lysine and histidine, together with alanine, proline, cystine, tryptophane, etc., have been discovered as hydrolytic decomposition products of proteins, both by the action of pancreatic juice and by boiling dilute acids, in addition to the earlier known leucine, tyrosine, glycocoll, aspartic and glutaminic acids, etc. Further, it has been shown that pancreatic juice in artificial digestion experiments, if sufficient time be allowed, is able to bring about a complete breaking down of the protein molecule into these relatively simple amino-acids, so that the biuret reaction, for example, entirely disappears. For a time, this extremely significant fact was not accredited with much importance physiologically; it was interesting; it testified to the general lability of the protein molecule and it threw light on the nature of the building stones which make up the protein complex. Then came, as many of you know, the comparatively recent discovery by Cohnheim of the enzyme erepsin in the duodenal mucous membrane; an enzyme which

acts especially on secondary proteoses and peptone, breaking them down quickly into amino-acids. This enzyme is naturally present in the intestinal secretions, becomes mixed with pancreatic juice, and is able to reinforce the latter in the complete destruction of the food proteins in the intestine, the final products being simple amino-acids and their combinations known as polypeptides.

Now, we understand why proteoses and peptone are not normally present in the circulating blood, even of the portal vein. We see that it is no longer necessary to assume a construction of blood proteins from absorbed proteoses and peptone. The old dictum, so often quoted, that the proteins of our muscle tissue, for example, are simple transformation products of the various food proteins no longer satisfies us, since it is so out of harmony with observed facts. We see opening up before us a totally different conception of the process of digestion so far at least as it relates to protein food. It has been a long period of time since the discovery of the proteolytic enzyme of the gastric juice by Schwann, or the early work by Claude Bernard on pancreatic juice. Slowly, but surely, however, our knowledge has progressed, until to-day we are on the threshold of a new vista; new paths spread out before us filled with the light of truth and they bid us hasten to clear away the accumulated misconceptions of the preceding years.

Think for a moment what the new facts lead to in their bearing on nutrition! Recall how we have come to understand that the specific immunities and specific reactions of the blood of different species are properties which reside in the individual blood proteins, and that these peculiarities are associated with the chemical constitution of the proteins. Every physiologist knows how greatly blood from different species varies, and we may safely say that each species of animal probably possesses blood characterized by a personal coefficient in the constitution of its proteins, upon which rests in some measure at least its physiological individuality. In the light of such suggestions is it not difficult to conceive of the varying food proteins of our daily diet being merged into the specific proteins of blood and tissue through simple transformation into closely related proteoses and peptones? Can their individuality be so easily lost by such a superficial alteration? No, the facts at our disposal to-day clearly indicate that the proteins taken as food can not find a place in the economy of the animal body until (as aptly expressed by Leathes) they have been, as it were, melted down and recast. Stated in different language, it is apparently the purpose of digestion, through the enzymes, pepsin, trypsin and erepsin, to thoroughly dismember the protein molecule so that no vestige of its original structure remains; while out of the many fragments or chemical groups so split apart the body can reconstruct proteins adapted to its own particular needs. This means synthesis of a most marked kind, quite

different in character from that implied by the hypothetical transformation of absorbed proteoses and peptone in the mucous membrane of the intestine. Further, there is suggested a far-reaching application of this synthetical power in the construction of tissue protein throughout the body.

Let us grant that in the intestinal walls or elsewhere the serum albumin and globulin of the blood are constructed *de novo* from the many simple fragments split off during the processes of digestion, what then is the origin of the many different forms of protein, nucleoprotein, etc., which characterize the various tissues and organs of the animal body? Do these result from simple transformation of the blood proteins which, as we are wont to say, nourish the active cells of the body and serve as pabulum for the hungry tissues?

No account has been commonly taken of the fact that these proteins of the blood must be taken to pieces and again put together, rearranged on a different plan, if they are to serve for the making of proteins and nucleoproteins in the cells of the muscles and other organs in which the destructive changes of life are felt. The proteins circulating in the blood are a currency which is not legal tender. And no account has been commonly taken of the familiar fact that when no food is obtainable, certain organs maintain for themselves a normal composition at the expense of the substance of other organs. When the spleen, liver, or the muscles of the limbs dissolve away in starvation, the heart feeds on what they supply. Are the proteins of these organs converted into serum albumin and globulin, or are they melted down by autolytic processes into the same cleavage products as are formed in the digestion of food, and in this form thrown into the circulating blood, which is thus in a position to supply the heart and diaphragm with just what they are accustomed to receive in the blood from the digestive organs? (Leathes.)

In attempting to answer this question, I need only call to your attention the many data collected during the past few years concerning autolysis in general; in which it has been found that practically all the organs of the body are capable under suitable conditions of undergoing auto-digestion, with formation of essentially the same cleavage products as result from the breaking down of proteins in the gastro-intestinal tract. Further, the ferments or enzymes that are responsible for these autolytic transformations have been in some measure isolated and separated from each other. When these facts were first brought to light, it was assumed that the changes in question were mainly at least the result of post-mortem conditions, but there is no justification for such an assumption. Intracellular enzymes are a part of the natural equipment of living cells, and metabolic events, nutritional changes, such as characterize the life and activity of tissues and organs in general, are undoubtedly due to the power of these agents, normally controlled, however, by a variety of conditions that must tend to balance conflicting interests. We can well imagine that in the life and death of tissue cells autolytic decompositions are constantly taking

place whereby cell protein is broken down into its component parts, while at the same time a synthesis of protein may be occurring from other amino-acids brought by blood or lymph with a possible utilization of some of the fragments liberated by the autolysis. In other words, our conception of nutritional changes to-day embodies the hypothesis of a synthesis of protein throughout the body; that it is a function of every living cell, "each one for itself, and that the material out of which all proteins in the body are made is not protein in any form, but the fragments derived from proteins by hydrolysis, probably the amino-acids, which in different combinations and different proportions are found in all proteins, and into which they are all resolved by the processes, autolytic or digestive, which can be carried out in every cell of the body" (Leathes).

Here, we have presented several points of view which are radically unlike the old-time traditions concerning nutrition. Objects and methods are both out of harmony with the long prevalent conception of the plan of the living organism in which oxidation was confessedly the ruling power. Profound and progressive hydrolytic cleavage is now seen to be the purpose of digestion, as well as of the autolytic processes which are associated with all the tissues and organs of the body; a cleavage which proceeds until the complex protein is split apart into its simplest chemical groups or components. In this process there is no sign of direct oxidation, but hydrolysis appears in the foreground, and by this means the rock protein is broken asunder into small fragments of definite shape, each of which can be used in the construction of fresh protein. Especially noteworthy is the harmony of action between the enzymes of the digestive tract and those of the living tissues of the body. Both have the same object in view; there may be differences in the rate of action, but in the end essentially the same simple fragments result. Again, what a suggestion of broad constructive power in the cells of the animal body; what a powerful synthetical process that by which the animal cell manufactures the most complex substance of its body protoplasm! For years the chlorophyll-containing cell of the plant world enjoyed the distinction of being the main laboratory in nature for the synthesis of organic compounds. The animal body could transform and modify, it could even accomplish a mild form of synthesis, such as a combination of two large molecules to form a still larger conjugate, but anything like a true synthesis, *i. e.*, the formation of a well-defined complex, such as protein, out of simple amino-acids was far beyond our imagination, until now accumulated facts seem to open up a new point of view.

Are we really warranted in accepting this modern conception of protein synthesis in the animal body? Are the facts available sufficient to substantiate the claim advanced? Physiologists quickly recognized

the necessity of confirmatory evidence on this important matter, for a hypothesis so far-reaching in its significance demands careful consideration before it can be given much credence. We understand full well that protein is an essential foodstuff, without which life can not be maintained. We have been accustomed to consider that no other form of nitrogen than protein-nitrogen can supply the physiological needs of the body. If, however, it is true that in normal digestion the protein molecule is completely broken down into relatively simple fragments, non-protein in nature, *i. e.*, into amino-acids and polypeptides, and that from these fragments specific proteins are reconstructed, then it is plain that animals fed on a diet free from protein, but with a proper amount of these nitrogenous cleavage products, should live and thrive, assuming, of course, a sufficient addition of non-nitrogenous food. Experiments after this order have been tried by various investigators, with very interesting results. Dogs, for example, fed on a mixture of protein cleavage products with suitable addition of fat and carbohydrate, maintained nitrogen equilibrium and even stored up nitrogen, presumably in the form of protein, thus indicating that the animals were able to utilize these end products of protein decomposition in much the same way as protein food would be utilized. The only logical supposition is that the dogs were able to manufacture body protein out of this composite of protein fragments; *i. e.*, a synthesis of protein took place; otherwise it would have been impossible to maintain a condition of nitrogenous equilibrium even for a day. Similarly, white rats gained in weight and stored up nitrogen on a diet in which the protein of their food was entirely replaced by the digestion products formed by trypsin and erepsin. Abderhalden and Rona,[5] using a dog as subject and feeding the products formed by pancreatic digestion of casein, viz., the amino-acids and other biuret-free products, found it possible to prevent completely the loss of body protein, a further proof of the power of the animal organism to synthesize protein from its final cleavage products.

Experimental evidence of this character forces us, whatever our preconceived notions, to admit the power of the animal body to build up its needed protein out of the relatively simple decomposition products into which the various forms of food protein are broken down by the processes of digestion. Oxidation does not appear—on the surface, at least—but progressive hydrolytic cleavage is the key-note. The food protein, like a crystalline geode, is split apart into numerous crystalline fragments by action of the several digestive enzymes to which it is exposed in the gastro-intestinal tract, and from these fragments the body cells apparently select such as are required to construct the specific proteins needed for the replacement of those used up in the processes of life. The hydrolytic cleavage induced by these digestive

[5] *Zeitschrift f. physiologischen Chemie*, Band 44, p. 200.

enzymes is, however, in some measure peculiar, in that the fragments are not wholly akin to those formed by hydrolysis with acids. When a given protein is boiled with a dilute acid it is speedily broken down and many of the fragments are identical with those produced by the action of trypsin and erepsin. Thus tyrosine, leucine, arginine, lysine, histidine, etc., appear in both cases, but the enzymes presumably leave intact certain groups or combinations which acids break up or in some way modify. As a result, it is found that the cleavage products formed from casein, for example, by acids, will not take the place of casein, or the products formed by trypsin proteolysis, in meeting the needs of the body. On a diet of protein cleavage products formed in this manner the animal steadily loses nitrogen; it is impossible to maintain a condition of nitrogenous equilibrium, since for some reason the tissue cells can not synthesize protein from the mixture of fragments produced by acids. We may conjecture that while in acid hydrolysis the products are all simple amino-acids, in enzymolysis combinations of the amino-acids, *i. e.*, polypeptides, remain intact. There is experimental evidence that such is actually the case, but equally good evidence seems to show that the presence of polypeptides is not essential for the synthesis of protein by the animal body. Thus, Henriques and Hansen found that by treating the mixed products of pancreatic digestion with phosphotungstic acid, which precipitates, so far as at present known, all the basic bodies including polypeptides, the mixture of monoamino-acids and possibly other nitrogenous substances contained in the filtrate is apparently able when fed to keep animals in a condition of nitrogen equilibrium. Further, the same investigators found, on treating the nitrogenous products (free from biuret reaction) of pancreatic digestion with strong alcohol, thereby separating the substances into two portions, the alcohol-soluble part was quite able to maintain animals in nitrogen equilibrium, *i. e.*, it was equivalent in action to the original protein, while the portion insoluble in alcohol was wholly ineffective. It is thus apparent that all of the fragments resulting from proteolysis are not needed for the synthesis of protein; there are apparently certain products that are not essential or not immediately necessary. On the other hand, it is equally apparent that in the more profound breaking down of proteins by acids, something is done which constitutes a physiological obstacle to utilization of the products in the synthesis of protein by the animal body.

As stated by Leathes:[6]

> The great bulk of the substances set free in the hydrolysis of proteids by enzymes and by acids are the same, and these substances enter into the composition of the proteids synthesized in the body in similar proportions to those in which they occur in the proteids of the food. For the present, all we can

[6] "Problems in Animal Metabolism," 1906, p. 132.

say is that there appears to be some kind of linkage between certain groups in the proteid molecules which is not uncoupled by the enzymes in the body, and that when it is uncoupled, as in acid hydrolysis, then it is impossible for it to be coupled up again in the body. This combination, which the cells can neither take to pieces nor put together again, must be present, in order that the other component parts of the proteid molecule may gather about them and group themselves round them when the synthesis of proteids is to occur. These considerations appear to suggest that the synthetic processes here involved may be the work of the same agent as the hydrolytic, the limitations in its hydrolytic power determining the limitations of its synthetic activity, as in reversible zymolysis.

Whether this conception of the matter is wholly correct we can not say, but at all events it is a suggestion as plausible as any that can be offered at the present time.

Just here we may advantageously consider the nature and proportion of the chemical components present in the protein molecule so far as has been ascertained by hydrolysis with acids. Recently, much work has been done on this subject, especially by Dr. Thomas B. Osborne at New Haven. The accompanying table gives the results with eight typical proteins from the animal and vegetable kingdoms, which may be taken as representative of the present state of knowledge.

PERCENTAGE YIELD OF CLEAVAGE PRODUCTS

	Gelatin[1] Bone	Casein[2] Milk	Excelsin Brazilnut	Hordein Barley	Phascolin Bean	Gliadin Wheat	Glutenin Wheat	Leucosin Wheat
Glycocoll	16.5	0	0.60	0	0.55	0	0.89	0.94
Alanine	0.8	0.9	2.33	0.43	1.80	2.00	4.65	4.45
Valine	1.0	1.0	1.51	0.13	1.04	0.21	0.24	0.18
Leucine	2.1	10.5	8.70	5.67	9.65	5.61	5.95	11.34
Proline	5.2	3.1	3.65	13.73	2.77	7.06	4.23	3.18
Phenylalanine	0.4	3.2	3.55	5.03	3.25	2.35	1.97	3.83
Aspartic acid	0.56	1.2	3.85	+	5.24	0.58	0.91	3.35
Glutaminic acid	0.88	11.0	12.94	36.35	14.54	37.33	23.42	6.73
Serine	0.4	0.23	0	.....	0.38	0.13	0.74	.....
Tyrosine	0	4.5	3.03	1.67	2.18	1.20	4.25	3.34
Arginine	7.62	4.84	16.02	2.16	4.89	3.16	4.72	5.94
Histidine	0.40	2.59	1.47	1.28	1.97	0.61	1.76	2.83
Lysine	2.75	5.80	1.64	0	3.92	0	1.92	2.75
Ammonia	.....	.....	1.80	4.87	2.06	5.11	4.01	1.41
Tryptophane	0	1.5	+	+	+	+	+	+
Cystine	.....	0.06	0	+	.....	0.45	0.02	.....
	38.61	50.42	61.09	71.32	54.27	65.80	59.68	50.27

All the above data from vegetable proteins were furnished by Dr. Thomas B. Osborne and represent his own work and that of his co-workers.

Perhaps the most impressive fact, certainly the one most quickly discernible, is that a large fraction of the protein molecule, 28–50

[1] Emil Fischer, P. A. Levene and R. H. Aders.

[2] Abderhalden. Cow's milk.

per cent., is of unknown composition. It is not unaltered protein, of that we can be sure, because all protein is destroyed in the hydrolysis. It is presumably composed of small fragments of some kind, not yet recognized by chemists. The next most noticeable feature is that no two of these proteins are alike in their chemical make-up. Proteins from the same grain are distinctly unlike; gliadin of wheat contains no lysine, while leucosin from the same kernel contains 2.75 per cent. of this basic substance; gliadin likewise contains 37 per cent. of glutaminic acid, while leucosin has less than 7 per cent.; gliadin shows 5.6 per cent. of leucine, and leucosin twice that amount; gliadin contains no glycocoll, while leucosin has nearly 1 per cent. of this amino-acid. Such marked differences in chemical composition speak plainly regarding the individuality of proteins, even of those which are associated in the same seed. Comparison of casein from cow's milk, as a typical animal product, with any of the vegetable proteins, brings to light equally strong points of difference, while in gelatin we see many of the familiar amino-acids reduced to a minimum or entirely lacking. While it is undoubtedly true that all proteins possess certain features in common, it is becoming strikingly manifest that they are more or less divergent in chemical constitution. It has been the custom of physiologists in the past to lay stress upon the general rule that proteins are substances capable of meeting the physiological necessities of the body and that their nitrogen exists in a form suited to the needs of the organism. We have been accustomed to point to gelatin as the one exception to the rule, and have classed it as a protein-like substance, with as much nitrogen or even more than most proteins, but not truly a protein, since it can not support life. I fancy, however, that many true proteins may prove, when taken alone, unable to support life. As a matter of fact, few isolated proteins have been tested in this respect. Most of our feeding experiments have been made with mixtures of proteins, and consequently a considerable variety of protein cleavage products have been available for nutritive purposes. Take, as an illustration, the zein of corn meal, which contains no tryptophane, glycocoll nor lysine whatever, and only 1.5 per cent. of arginine and histidine combined, but with 18.6 per cent. of leucine, to say nothing of other peculiarities of chemical structure. Is it not reasonable to suppose that such a protein, with so many of the ordinary chemical groups missing or in greatly diminished quantity, will prove inadequate to meet the demands of protein synthesis? Experiment with animals has, indeed, shown this to be the case.

Data along these lines are bound to bring us more definite information than we at present possess regarding the real merits of vegetarianism as contrasted with the use of animal foods. At present, so-called vegetarianism rests mainly upon sentiment, reinforced by the

belief that the quantitative needs of the body for protein food are more satisfactorily met by a liberal addition of vegetable matter with its larger calorific or heat-producing power and smaller nitrogen content. In view, however, of what has been stated concerning the divergent chemical structure of individual proteins, it is obvious that a new standard of comparison is at hand, the suggestions it may offer to be tested by appropriate feeding experiments on man and animals. Truly, no chapter of nutrition is more deserving of careful consideration, both from a scientific standpoint and from its bearing on the welfare of the human race, than that which deals with the relative capabilities of the various proteins of animal and vegetable origin.

In all that has been said we see emphasized the ability of the living organism to break down its complex food material, as well as the corresponding material of its tissues and organs, into the simplest of chemical fragments, coupled with the capacity to construct equally complex tissue material out of the fragments so produced. Profound and progressive hydrolysis, rather than simple oxidation, is the method of decomposition, for many of the fragments at least are to be carefully conserved for future use. Oxygen, however, may play its part in connection with the smaller groups, though even here enzyme intermediation may still be found a ruling factor. Enzymes are to be detected on all sides, both inside and outside the cells of the individual tissues and organs, and it is through their agency that the varied processes of life are carried forward. The present realization of the profound part played by enzymes in the reactions of the animal body is completely transforming our views of life. The so-called vital activities of living tissue or its component cells are no longer shrouded in that mystery which defies explanation, but we see within our reach tangible means of unraveling the complexities of cellular activity. One by one, the old views of living matter and organic structure are giving place to truly scientific conceptions that admit of logical interpretation. It is not long since, when chemists and physiologists alike viewed with enthusiasm, akin to awe, the production of an organic compound by synthesis in the laboratory. I well remember meeting the renowned Wöhler, then an old man, in one of my early visits to Göttingen. Yet, Wöhler was the first to make an organic substance by synthesis. Up to his time, physiologists all believed that organic substances, whether simple or complex, could be formed only through the agency of a living organism. To-day, however, there is almost no limit to our power of producing organic substances by purely chemical synthesis. In the hands of the chemist, many of the reactions of living matter may be duplicated and we are led to see that the living organism makes use of processes which are merely a counterpart of those we have learned to control in the laboratory.

When Buchner a few years ago, by simple pressure, forced from the yeast cell a little limpid fluid and with this was able to induce the same chemical reactions that the living yeast plant produces when brought in contact with a sugar solution, it became clear that the typical formation of alcohol and carbon dioxide is not the result of the *life* of the yeast plant as formerly supposed, but is instead to be attributed to something—a chemical substance—easily separable from the yeast cell, and quite capable of causing the fermentation of sugar. This reaction, which had for so long been looked upon as a typical illustration of the power of life in inducing chemical change, is merely a simple process of enzymolysis. The yeast plant, it is true, produces the enzyme; but the isolated ferment, once formed, is just as capable of decomposing the sugar as the yeast plant itself. Indeed, the latter is able to accomplish this chemical reaction, solely because of the presence of the enzyme or ferment, now called zymase. In all forms of animal and vegetable tissue, intra- and extra-cellular enzymes abound; enzymes of varied nature, endowed with the power of inducing chemical reactions of diversified character. Those previously referred to in the breaking down of protein material, both in digestion and in autolysis, are typical of what may be found in many of the fluids and in most of the tissues of living organisms. Enzymes which induce hydrolytic cleavage are especially abundant; sugars, proteins and fats all falling as prey to their power of breaking down the respective molecules into smaller and simpler ones better fitted for distribution or utilization. Further, enzymes of the amidase type, which have the power of removing nitrogen from nitrogenous compounds, are equally conspicuous in many phases of intermediary metabolism, especially where changes of nuclein material are involved. In this reaction the elements of water are apparently alone involved, but in some mysterious fashion the enzyme causes a retention of oxygen while the hydrogen passes off with one atom of nitrogen in the form of ammonia, thus leading to the formation of a new substance with one more atom of oxygen than the body from which it was formed and with one less atom of nitrogen and of hydrogen. In this way, gradual oxidation results without free oxygen being involved, while at the same time the content of nitrogen is reduced. Again, there are enzymes separable from the tissues of the body which bring about the destruction of uric acid, not, however, by a process of annihilation, as might be implied by the above statement, but by a method of cleavage in which new bodies less complex are formed. Equally manifest is the action of enzymes which bring about glycolysis, *i. e.*, the destruction of sugar as in the blood; while the separation of the amido group from amino-acids, the oxidation of aromatic aldehydes, the splitting apart of a substance like arginine into urea and ornithine, and a host of kindred reactions, all

testify to the multitude of chemical changes that the enzymes of the animal body are capable of producing.

Turn for a moment to the oxidation of an amino-acid such as leucine, which is well known as a product of pancreatic digestion. As this process is carried out in the body under the influence of specific enzymes it is quite different from the ordinary conception of oxidation or combustion. Instead of a complete destruction of the molecule, there is first a removal of ammonia and of carbon dioxide, followed by the formation of an aldehyde and an acid free from nitrogen, together with acetone. The same kind of a reaction can be induced outside the body by some mild form of oxidation, as with hydrogen peroxide, as has recently been shown by Dakin. Here we have a series of reactions, in which an amino-acid by successive oxidation yields a row of non-nitrogenous substances such as are found in the intermediary metabolism of the body, *i. e.*, an aldehyde, an acid, and finally acetone, nitrogen being removed from the molecule in the early stage of the process. Such facts as these throw light upon the methods of oxidation as they occur in the living organism, and they teach us to understand that animal oxidation is quite different in character from the old-time conception of the process. The amount or volume of oxygen has no influence on the character of the change produced, but the specific enzyme exercises a controlling power by means of which a progressive, gradual change is induced leading to the formation of a row of kindred substances of more or less physiological significance.

In other words, the oxygen so freely drawn into the lungs at every inspiration is not directly responsible for the oxidations that take place in the body. Animal oxidation is a roundabout process, in which food and tissue material are first through the agency of numerous enzymes subjected to a variety of changes whereby easily oxidizable decomposition products are formed, which may eventually succumb to the influence of oxygen; even here, however, enzymes of the oxidase type may prove to be the controlling factor in determining whether or not oxidation results.

The "spontaneous combustion" of hay affords a striking example of the activity which oxidation of the organic foodstuffs may attain when decomposition of the latter has previously set in. If hay is stacked before it is thoroughly dry, decomposition begins in the middle of the damp stack through the action of organized or unorganized ferments. As all decomposition by ferments is accompanied by hydration, drying is the best means of preventing it. Heat is liberated by the decomposition, and proportionately with the rise in temperature in the middle of the stack an ever-increasing accumulation of easily oxidizable decomposition products is formed. If the hay be now disturbed so that there is free access of atmospheric oxygen to the internal parts of the stack, the whole blazes up and is consumed.[1]

[1] Quoted from Bunge: "Text-book of Physiological and Pathological Chemistry," 2d edition, 1902, p. 252.

In the animal body, however, there is no such accumulation of decomposition products as is implied here, but the principle involved may possibly admit of application.

It is generally understood that muscular energy comes primarily from the decomposition or oxidation of non-nitrogenous material, either of the food or of the tissues; and in man we are accustomed to measure the amount of muscular work performed by the amount of oxygen consumed and the amount of carbon dioxide thrown out. In other words, the potential energy of the foodstuffs is made available through oxidation. This, however, is not always the case. Thus, in *Ascaris,* a round worm inhabiting the intestine of some of the higher animals, we have an animal that can live and show extremely active movements for days at a time without any appreciable amount of oxygen. Carbon dioxide is given off abundantly, however, thereby implying a cleavage or process of disintegration in which energy is freely liberated for the necessities of the animal's machinery. It is quite apparent, however, that oxidation is not the source of muscular energy in these organisms. It may be claimed, and perhaps justly, that such an illustration as this can not be applied legitimately to animals higher in the scale of life, yet there is experimental evidence from various sources pointing in the same direction. Thus, Stoklasa[10] has shown that organs from the higher animals, notably the lungs, liver, pancreas and muscle, yield on pressure fluids, from which by precipitation with alcohol and ether enzymes can be separated, having the power of producing in perfectly sterile solutions of sugar—and with exclusion of micro-organisms—alcoholic fermentation. The proportion of carbon dioxide and alcohol formed under these conditions is the same as produced by yeast. Remembering that in alcoholic fermentation sugar is simply split apart into alcohol and carbon dioxide, it is readily seen that the liberation of a certain amount of energy is possible by simple cleavage of the sugar molecule and without the intervention of oxygen. This then is a form of anaerobic metabolism or respiration, possibly analogous to that which occurs in *Ascaris,* where carbohydrates are broken down and energy set free for the needs of the organism. Again, Hermann years ago proved that a freshly excised muscle, from which all free oxygen had been separated by exposure to a vacuum, when placed in an oxygen-free medium could be made to work and give off carbon dioxide. Other data of a similar nature might be presented showing quite conclusively the power of animal tissues to carry on various decompositions of complex organic matter with an output of carbon dioxide and with consequent liberation of energy where free oxygen is entirely wanting. These are facts, however, well known to physiologists, but they serve to emphasize the validity of the present

[10] *Zentralblatt für Physiologie,* Band 17, p. 465.

point of view, viz., that the processes of animal metabolism are peculiar and are by no means always concomitant with ordinary oxidation. Outside the animal body, the customary components of our daily food, the proteins, fats and carbohydrates, are not affected by oxygen even at the body temperature or by long exposure to the gas. Catalytic action is a necessary prelude to their oxidation, and it is the smaller molecules resulting from the action of enzymes working through catalysis that are mainly burned up or broken down with liberation of their contained energy.

The processes of nutrition are truly complicated, and we can readily conjecture that their harmonious working is dependent in large measure upon the integrity of many closely related operations. Enzymes must be elaborated in due proportions, both in digestive secretions and in tissue cells; proper conditions for enzymolysis must prevail at the places where the reactions take place, since enzymes are extremely sensitive to their environment and fail to work unless all the requirements are fully met; proper conditions of circulation of blood and lymph must be maintained, in order to supply fresh pabulum and to prevent undue accumulation of the products of enzymolysis. In short, there are a multitude of accessory reactions to be preserved in their proper sequence and normal rhythm if perversions of nutrition are to be avoided. Many a substance known to have a deleterious effect upon nutrition does so in virtue of its action upon some one or more enzymes with which it may be brought in contact in the body. Take, for example, the well-known influence of alcohol as a factor in the causation of gout. In this disease, there is an increased amount of uric acid in the system, due in part to an inhibition of its oxidation and consequent destruction. When alcoholic fluids are taken, together with an excess of meat or kindred animal foods, the kidneys at once excrete increased amounts of uric acid, in harmony with the increased content in the blood. It is a well-known fact that alcohol interferes with the oxidative processes in the liver. It is equally well known to-day that the liver and other organs contain an enzyme, or more specifically an oxidase, which has the power of oxidizing uric acid to urea and other products. After the ingestion of alcohol and animal foods rich in uric acid precursors, the notable increase of uric acid in the blood and urine is considered as due to the inhibitory action of alcohol on this oxidase, which under normal conditions causes more or less destruction of uric acid. The failure of the enzyme to accomplish its ordinary duty naturally results in an accumulation of uric acid in the system, although the kidneys plainly endeavor to meet the new conditions by increased elimination. Hence, we see that the predisposition to the development of gout caused by the ingestion of a high protein diet reinforced by alcohol is to be explained in part at least by the direct

influence of alcohol on this oxidizing ferment which is normally charged with the destruction of any surplus of this deleterious substance. Here we have a definite and logical explanation of an abnormal condition where interference with the routine action of a tissue ferment or enzyme is one of the specific causes of the disturbance.

This is one of many illustrations that might be cited showing how alterations in the environment of the enzymes occurring in the body may modify the rate of action, either by stimulation or inhibition, and thereby pave the way for marked disturbances of nutrition. It is easy to see also how the many enzymes which rule the normal nutritional processes of the body may need control in order to prevent undue activity, or excessive enzymolysis, with consequent disturbance of the normal nutritional rhythm. Nature has apparently provided this protection by a row of anti-bodies widely distributed which serve as specific antiferments, and either prevent undue alteration or check entirely the action of a given enzyme in certain localities where its action would be detrimental. We find illustrations of such antiferments in the gastro-intestinal tract, by the presence of which the digestive enzymes are restrained from attacking the proteins of the tissue cells, composing the lining membranes of the intestine. Apparently, there is no reason why the enzymes pepsin, trypsin, etc., which digest so vigorously the various protein foodstuffs should not attack with equal avidity the related proteins present in the mucous membranes of the stomach and small intestine. This, however, does not occur during life, no matter how strong the digestive fluids that are secreted into the digestive tract, partly at least because of the inhibitory effect of the natural anti-bodies that are present in the membranes. Again, it is interesting to note that just as antitoxins are produced in the animal body by the injection of a proper amount of toxin into the system, so likewise antiferments can be formed by injection subcutaneously of specific enzymes. Thus, as Morgenroth found, if the enzyme rennin which coagulates milk be injected under the skin of an animal in small doses, after a time the blood serum of the animal so treated will contain something which hinders or prevents the coagulation of milk. In other words, an anti-rennin is formed, just as under similar conditions an antitoxin may be produced. We thus see a close similarity or analogy between the production of a specific immunity toward a given toxin and the formation of antiferments.

Finally, we may again emphasize the specific character of the many ferments that play such an important part in the nutritional processes of man and the higher animals. We readily understand that an enzyme capable of acting upon proteins is quite ineffective when brought in contact with a carbohydrate, or that an enzyme able to digest one form of sugar can not attack even a closely related sugar belonging

to the same group. The specificity of enzymes, however, extends farther than this, being intimately connected with the chemical configuration of the molecule acted upon. As a rule, generally accepted to-day, it is understood that living organisms, both animal and vegetable, work mainly with optically active carbon compounds, *i. e.*, compounds in which there is at least one asymmetrical carbon atom. As Kossel has expressed it, the asymmetry of the cell building stones begins the moment of the assimilation of carbon dioxide from the atmosphere by the chromophyl-containing plant cells, from whence it is carried directly to the herbivorous and indirectly to the carnivorous animals. In other words, enzymolysis as it occurs in the animal body is bound up with the chemical constitution and configuration of the substances undergoing change, so that only those substances can be transformed or decomposed that have a certain definite plan of structure. It is thus clear that the processes of nutrition are carefully ordered and clearly defined, while to follow their many paths and interpret aright the signs by the roadside requires accurate chemical and physiological knowledge.

From the early conceptions of nutrition as embodied in the work of Lavoisier and his immediate successors, we have traveled a long way. From vague generalizations based on erroneous views and faulty reasoning, we have passed to a period of scientific activity, where thoughtful observation and careful analysis have contributed to a broader and clearer understanding of the ways of nature. New points of view lie before us pregnant with meaning and full of suggestions for future work. Let us gather together all the facts available, search far and near for all the data that can be obtained bearing upon the question at issue, remembering that progress can come only from intensive and persistent investigation, and that conclusions bearing the imprint of truth must be based upon accurate knowledge. It is only when we lack knowledge that we are liable to be led astray by vain imaginings. How clearly this is illustrated by the experience of the renowned Harvey who when he was arriving at a true understanding of the circulation of the blood, by patient inquiry and still more patient dissecting, was constantly confronted by the crude and illogical views based entirely upon the speculation then prevalent! His many critics who lacked sufficient knowledge to be impressed by his careful demonstrations and who were moreover dominated by the prevalent belief in the spirits provoked from him this statement:

> With reference to the third point, or that of the spirits, it may be said tnat, as it is still a question what they are, how extant in the body, of what consistency, whether separate and distinct from the blood and solids, or mingled with these—upon each and all of these points there are so many and such conflicting opinions, that it is not wonderful that the spirits, whose nature is thus left so wholly ambiguous, should serve as the common subterfuge of

ignorance. Persons of limited information, when they are at a loss to assign a cause for anything, very commonly reply that it is done by the spirits; and so they bring the spirits into play upon all occasions; even as indifferent poets are always thrusting the gods upon the stage as a means of unraveling the plot, and bringing about the catastrophe.

Fernelius, and many others, suppose that there are aerial spirits and invisible substances. Fernelius proves that there are animal spirits, by saying that the cells in the brain are apparently unoccupied, and as nature abhors a vacuum, he concludes that in the living body they are filled with spirits, just as Erasistratus had held that, because the arteries were empty of blood, therefore they must be filled with spirits. But medical schools admit three kinds of spirits: the natural spirits flowing through the veins, the vital spirits through the arteries, and the animal spirits through the nerves; whence physicians say, out of Galen, that sometimes the parts of the brain are oppressed by sympathy, because the faculty with the essence, *i. e.*, the spirit, is overwhelmed; and sometimes this happens independently of the essence. Further, besides the three orders of influxive spirits adverted to a like number of implanted or stationary spirits seem to be acknowledged; *but we have found none of all these spirits by dissection, neither in the veins, nerves, arteries, nor other parts of living animals.*[11]

Here we have the point of view of the true investigator, the true scientific spirit. Abide by the facts and base your reasoning upon careful observation. Although Harvey lived at a period when physiological knowledge, as we understand it to-day, was almost wholly unknown, and when the influence of the "spirits" dominated all thought, yet he applied rational methods of scientific study and drew logical conclusions from his observations, with the result that to him belongs the honor of discovering the motion of the heart and the circulation of the blood. What he could not see he had no faith in, and so the theories concerning the spirits of the body he laid aside as having no foundation in fact. Would that to all of us might be given that same true appreciation of the importance of scientific observation upon which depends the advance of exact knowledge.

[11] Quoted from William Harvey: "An Anatomical Disquisition on the Motion of the Heart and Blood in Animals," translated from the Latin by Robert Willis. Everyman's Library, London and New York.

THE UTILIZATION OF AUXILIARY ENTOMOPHAGOUS INSECTS IN THE STRUGGLE AGAINST INSECTS INJURIOUS TO AGRICULTURE

II

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Generalization of this Method. Different Applications

THE striking success brought about in the struggle against *Icerya* by the use of *Novius cardinalis* gave rise to great enthusiasm in favor of the method of fighting injurious insects by their parasites.

First in California, then in Australia and the Hawaiian Islands, under the auspices of Alex. Craw and his adepts, the application of this method became popular and enjoyed extreme favor. From the facts just given, they generalized to excess and imagined that in collecting beneficial insects and naturalizing them in the country where they proposed to use them, they would be able to check completely the plagues of agriculture.

Fight against the Fruit Fly. Compere's Mission.—No example appears to us to show better the belief inspired by this new method, the exaggerated hopes to which it gives birth, and the zeal with which it fills its promoters, than the incredible Odyssey around the world of Mr. Compere, charged at the beginning of 1903 by the government of West Australia with a mission having for its end the search for the home of the fruit fly (*Ceratitis capitata*), and of finding the parasites which in its original home should limit its propagation. This fly, which is a great plague to fruit culture in South Africa, and which has also invaded western Australia, has also for us an interest, since it is abundant in all the Mediterranean regions where it is particularly injurious to oranges in Algeria and Tunis, and which several years ago even made its appearance in the suburbs of Paris, where it attacks peaches and apricots. The *Ceratitis* has for a long time existed in Mediterranean countries, and it is from this region that it was probably transported to the Cape of Good Hope and to Australia.

It would seem, then, natural to direct one's observations first to this locality. Nevertheless, the damage accomplished by this insect in the Mediterranean region appears to be too large to warrant the conclusion that this is its original home. Spain having received the famous fly from one of its colonies, one naturally thinks of the Philip-

pines; and these islands not being very far from Australia, Compere started then for that archipelago. He only passed through there, and then visited China and Japan without meeting the *Ceratitis*. From Japan he went to the United States, where the fly in question does not exist, but where in the collections and the laboratories he thought to gain facts which should throw some light upon the problem of its origin. From there he went to Spain, and there tried to learn from what region this country received the fruit fly. He was not able, however, to get any knowledge of this kind, but a large number of fruit growers told him that they remembered the time when oranges, peaches and other fruit were not damaged by the larva of this insect. Was that not sufficient to confirm his opinion that the *Ceratitis* was a fly not indigenous to Spain?

After having traversed the south of France and Italy, he went back again to Australia, and shortly afterwards departed for the Indies. In the following month of September he landed at Bombay, traveling through Hindostan, visiting the great markets as well as the orchards and the principal fruit regions around Bombay, Calcutta, Madras and Ceylon, studying the flies of the different species of fruits, as well as the parasites living at their expense, wherever he could find them. Then, always without having found the *Ceratitis* and finding nothing which could serve him in the struggle against this insect, he returned to Australia persuaded from certain indications he had collected in the United States, that the original country of the celebrated dipterous insect was Brazil. The seventh of January, 1904, he sailed, then, for South America. Arrived in Brazil, he quickly ascertained that *Ceratitis capitata* exists there in company with other flies injurious to fruit, and at the same time he observed some Ichneumonids and some beetles of the family Staphylinidæ, which were carrying on a war against the flies. If the *Ceratitis* causes, in general, only slight damage in Brazil, it can be only owing to the presence of all these natural enemies which hold it in check. And it, therefore, resulted that Brazil was the promised land for the fervent entomological traveler, the original home of the Mediterranean fruit fly! Arranging as ample a provision as possible for the parasites and predatory enemies of this insect, and arranging for their food for the time necessary for their journey, he then returned to Australia.

On his arrival, the Staphylinids were set at liberty in one of the gardens of Perth, where the conditions seemed particularly favorable to insure their subsistence. The pupæ parasitized by the Hymenoptera to the number of about 200 were placed in breeding jars, and as the parasites emerged they were liberated in the orchards most infested by the fruit fly.

If we have told with some details this story of the journey around

the world of a practitioner, launched by his government into the search for the parasites of a fly, it is to show the vogue which the use of beneficial insects in the struggle against injurious insects enjoys in certain countries.

What will be the result of this experience? It is premature to express an opinion on the subject. The time necessary for the definite acclimatization of a parasite, and above all for it to multiply sufficiently to restrain the insect which it is its mission to attack, must be extremely variable, according to the species and also according to the extent of spread of the plague. It is only necessary for some months to elapse in the case of *Novius cardinalis,* but years may be necessary for such parasites as the Ichneumonids.

Utilization of Beneficial Insects in the Hawaiian Islands.—Journeys of Koebele.—The method of which we are speaking has nowhere been applied in a more extensive way than in Hawaii. These islands, ever fertile, present, as is well known, a climate extremely favorable for large number of tropical and subtropical crops. At the beginning of the American colonization, the only plants of economic importance were yams and cocoanuts, but since that time enormous numbers of useful plants, coming from all parts of the world, have been acclimatized in this rich country, and with them also have unfortunately been imported a large number of their natural enemies, among them, and the most important, scale insects and plant lice. It has been stated that the Hawaiian Islands are the paradise of these insects, since they are represented by numerous species coming from all parts of the world, which prosper there and flourish.

After having seen, in 1890, their orange and lemon trees relieved from *Icerya* by *Novius cardinalis,* the planters directed their efforts to this method in order to combat other agricultural plagues, and particularly the enemies of coffee and sugar cane.

They, therefore, gave Mr. Albert Koebele a commission to undertake this work. This entomologist, celebrated for his discovery of *Novius cardinalis,* and already employed at the same time by the State Board of Horticulture of California upon a similar mission, commenced by sending from California the Coccinellids which seemed most desirable for Hawaii, notably: *Hyperaspis undulata* Say, *Scymnus debilis* Lec, *Chilocorus bivulnerus* Muls., *Rhizobius ventralis* Er., and *R. lophantæ* Blaisd. The two latter became naturalized and constituted a useful resource for the country.

In 1893 he visited the islands and left immediately for Australia. From 1894 to 1896 he journeyed through Australia, China, Ceylon and Japan, and made during this journey numerous sendings of this insect to Hawaii and California. Among the best of these must be mentioned, in the first place, *Cryptolæmus montrouzieri* Muls., orig-

inally from Australia, where it had rendered inestimable service in destroying mealy-bugs (*Dactylopius, Eriococcus,* etc.), and which, introduced into the Hawaiian Islands, developed with a surprising rapidity, comparable to that of *Icerya* in California. This ladybird is there considered as one of the most important enemies of the scale insects of the coffee plantations, and particularly *Pulvinaria psidii,* one of the greatest enemies of this crop. *Coccinella repanda* is also naturalized and is to-day one of the most common ladybirds, and most efficacious among those which attack orange plant-lice and the plant-lice of Hibiscus and sugar cane.

In 1899, Koebele left for Australia and the Fiji Islands and made numerous sendings of ladybirds and different parasites to the Hawaiian Islands, notably to combat *Ceroplastes rubens* Mask.

At the end of 1902 the attention of planters was particularly directed to an injurious leaf-hopper on the sugar cane, *Perkinsiella saccharicida* Kirk. It was introduced from Australia in about 1897 and has since that time increased and spread and become a perfect plague for this important crop. The attempts made to introduce living parasites in California at the expense of similar leaf-hoppers having given unsatisfactory results, Koebele and Perkins left in the spring of 1904 for Australia, and during the course of that year sent to Hawaii a great number of insects parasitic or predaceous, and among them a considerable quantity of enemies of *Perkinsiella.*

Considering that the money appropriated by the government was insufficient, the Hawaiian Sugar Planters' Association did not hesitate to advance important sums in order to further the study of the question, and created itself a section of entomology in its experimental station, and has started a series of investigations exclusively upon the enemies of sugar cane and their parasites. Some remarkable monographs are now in course of publication.

The method of utilizing beneficial insects has been, during fifteen years, used with such activity that the list of useful insects which have been imported from one country to another, in order to combat the plagues of agriculture, is already very long.

We have already spoken of some of them in giving a résumé of Koebele and Compere. Omitting those which up to the present time have given only uncertain results, or which have not succeeded in naturalizing themselves, we will limit ourselves to a mention of some interesting species, either because they have fully justified the hopes founded upon their introduction, or because they appear likely to soon play an important rôle in the struggle against the enemies of agriculture.

Rhizobius in California.—Among the ladybirds must at once be mentioned *Rhizobius ventralis* Erichs. This little ladybird, of a spe-

cially dark color, very useful in Australia for the destruction of various scale insects, was introduced by Koebele into California while on his second mission to Australia in 1893. It naturalized itself and plays an important rôle in fighting the black scale of the olive. A hundred thousand of these insects were distributed in different districts. In different localities they multiplied in a prodigious way, and proved to be particularly efficacious in the moist climate of the seashore. Mr. Cooper, president of the State Board of Horticulture, had such confidence in the efficacy of this *Rhizobius* and other ladybirds that, yielding to a perhaps exaggerated enthusiasm, he renounced for a time all other intervention, and, in order to allow them to multiply at their ease, he suspended all treatment. According to him, to spray trees upon which there is *Rhizobius* is a crime and should be severely punished.[10]

Attempts to Fight the San Jose Scale by Means of Ladybirds.— The disasters caused by an insect commonly known as the San Jose scale in the United States are well known. The damage done to the fruit trees can only be compared in intensity to that done in our country by the Phylloxera, and about 1898, the fear that it would be introduced into Europe occasioned prohibitory, special legislation on the part of European states. Since it was a scale insect, it was natural to search for an enemy which would approximate the rôle of *Novius cardinalis,* but no one knew the original home of the San Jose scale.

Australia was considered for some years as responsible. Finally, they concluded that it might be Japan, and Mr. Marlatt, first assistant of the Division of Entomology, Department of Agriculture, was sent on a mission, in 1901–2, to the extreme orient to solve the question, and he established in a positive manner the fact that the original home of the San Jose scale was the north of China, where he found it occurring upon small wild apple trees, in the mountainous country. There he found, at the same time, with the scale insect a ladybird, *Chilocorus similis* Rossi, which, both in the larval and adult stages, feeds on the San Jose scale. This ladybird is an insect widely spread, not only in China, but throughout all of Asia and the south of Europe. The San Jose scale is, then, not its only food, but it can live at the expense of different scale insects. Therefore, samples of this insect, coming from China and offering the best possible conditions for adaptation to the struggle against the San Jose scale, were sent to Washington, and all precautions being taken, they were bred with great care in the Bureau of Entomology, first in cages and afterwards in an experimental orchard. They were thus produced in sufficient quantity, so that for several years they could be sent to different States. The colonies which were

[10] The attempt to acclimatize *Rhizobius ventralis* in India and Ceylon, undertaken by Froggatt and Green, did not succeed, probably on account of unfavorable climate.

established in the north did not succeed. But, on the other hand, colonies installed in the Georgia orchards and other southern states rapidly spread, naturalized themselves, and still fill a useful rôle in attacking the San Jose scale. However this may be, this importation can never be compared to that of *Novius cardinalis*. Mr. Marlatt himself states that this insect does not seem to have found in America, up to the present time at least, conditions as favorable to its development as in its native country. Moreover, the time when it was introduced coincided with the period of employment especially of the lime-sulfur-salt wash, and obviously the use of such an efficacious remedy should not be interrupted to allow the ladybird to spread.

Scutellista cyanea.—The success gained by beneficial parasites, properly speaking, is at present rare and less startling than those which the predaceous insects, and particularly ladybirds, have brought about. An especial rank, however, should be given to a Hymenopterous parasite of the family Chalcididæ, *Scutellista cyanea* Motsch., which is among the most useful of the American importations. It was first described from Ceylon, where it was found attacking parasites of the coffee scale. Then it was found again by Berlese in Italy, where it attacked the wax scale of oranges and other plants.

Howard, with the help of Berlese, tried in 1898 to introduce it into Florida and Louisiana, to combat the wax scale, injurious in that part of the country. This first attempt at acclimatization failed. In the meantime, Lounsbury, State Entomologist at the Cape of Good Hope, drew attention to this parasite as one of the most efficacious enemies of the black scale of the olive. The olive scale is not abundant enough at the Cape to be considered as injurious, and the damage which it does is always less than in America and particularly in California. On this account, and considering *Scutellista* to be the cause, the State Board of Horticulture of California, always looking for new assistance of this kind, tried to get this parasite. In 1900–01, branches carrying parasitized black scale were sent from the Cape to California. Some parasites were obtained by breeding from these different sendings, but their number was not sufficient to undertake a rearing in the large cage constructed around the tree infested by scales, but, in 1902, numerous colonies were sent into all the districts of the State of California where the black scale was injurious. Since 1903, numerous orchards have been found which have been practically cleaned of the black scale by this parasite. It may be affirmed that this introduction is one of the most fortunate ones for fruit growers in California.[11]

The Struggle in America, by means of Parasites, against the Gipsy

[11] The acclimatization of this insect appears also to have been brought about in Australia, where it was introduced in 1904, and in Hawaii, where it was imported in 1905. Mr. Lafont has lately announced the presence of this insect in France, where he considers it a very efficacious parasite of the black scale.

Moth and Brown-tail Moth.—If parasitic insects (hymenopterous and dipterous) are at the present time behind the predatory ones, it does not make their efficacy any the less that the work that they accomplish is not so immediate and is less easily brought about.

Everybody knows how some ladybirds will free a tree from plant lice or scale insects, while there is some trouble in observing how a parasitic insect lays its eggs in the interior of a caterpillar. Moreover, while the victims of a predaceous insect are killed immediately, the insects pierced by the hymenopterous insect continue in most cases to feed and grow, and it is only in the following generation that the good work can be seen. Finally, to appreciate the just value of parasites, it should be remarked that several species, in certain cases more than thirty, live at the expense of a single plant-feeding species and join forces to hold it in check. To reestablish the equilibrium in a country into which a plant-feeding species has been imported, not only one of these parasitic species, but as many as possible, should be sought for and should be naturalized.

In a few years we will be much more certain concerning the advantages to be drawn from the utilization of these beneficial species.

No experiment in any case can be better conceived to illustrate this question than the gigantic undertaking now carried on by the government of the United States which has for its object the importation of the European parasites of Bombycids, up to the present unmasterable scourges, which ravage without interruption the trees of Massachusetts.

These two insects, *Liparis dispar* and *L. chrysorrhœa,* are European insects which have been accidentally introduced into Massachusetts, the first in 1868, and the second in 1890. It is difficult to imagine the intensity of the ravages of these two insects. The damage occasioned by the first of them, which is popularly known in America under the name of the gipsy moth, is to-day celebrated in certain localities, notably in the suburbs of Medford, which was the first point of infestation. The caterpillars became so abundant that all the trees in the parks, woods and public streets were entirely defoliated, and presented, in midsummer, a winter aspect. These trees, deprived of their vitality, were killed by thousands. In certain suburban quarters, one could see the walls of the houses carpeted with caterpillars, and the roads themselves so invaded that it was impossible to walk without crushing them by hundreds. A special committee was started to organize the fight, and from 1889 to 1895, $525,000 was spent in work against the destruction of this species. For the year 1897 alone, $150,000 was voted by the legislature.

As to *chrysorrhœa,* known to Americans under the name of the brown-tail moth, although it has shown itself extremely injurious, it is

to-day eclipsed by its congener, and it is only in these later years that it has taken an importance of the first order, tending even in certain districts to take the first rank over the gipsy moth.

The caterpillars of these two species are extremely common in Europe, their original home. They are injurious and from time to time appear in great number. It is to be remarked that in a year following their large multiplication, the caterpillars of these insects become quite rare, and that they remain so for a long time. They are, then, very far from being responsible for damage similar to that which they cause every year on the other side of the Atlantic. With us their presence is tolerable, and they do not cause notice since they do not threaten the vitality of the trees. In Massachusetts, on the contrary, they constitute a permanent plague which has commenced to invade neighboring states.

The difference in these conditions appears to be that in Europe the insects are held in check by parasites, which are much more numerous than in the United States.

Some American parasites have adapted themselves to destroying the gipsy moth. There are 5 hymenopterous and 6 dipterous parasites, without counting several predaceous species which attack it. But this is small in comparison with the 27 hymenopterous and 25 dipterous parasites of the gipsy moth in Europe. While the parasites of the brown-tail moth are less known, it is perfectly sure that in Europe this insect is kept in check much more efficaciously by its natural enemies than is the case in America. On account of these considerations it was only natural to seek to introduce into Massachusetts the original parasites of these two insects. For a long time it was not judged wise to undertake the enterprise. A law obliging the systematic destruction of the gipsy moth and the use of insecticidal mixtures seemed to render it inadvisable. Moreover, there was confidence in the fact that the native parasites would increase. Now the conditions have changed. In 1900, the appropriations were stopped, at a time when the insect was well in hand. In five years, however, it has spread over a territory four times as great as that which it occupied in 1900 and has commenced to spread into the neighboring States of New Hampshire and Rhode Island.

On the other hand, in the 36 years that the insect had infested the country about Boston, American parasites, if efficacious, would have manifested it in an appreciable way. The same considerations applied to the brown-tail moth.

Americans resolved, then, to attempt a last and great effort to master the plague against which a long struggle had given insufficient results. In the appropriation bill of the Federal Congress, in 1906, $2,500 were appropriated to begin the importation of parasites of these two insects

into the United States. At the same time the state of Massachusetts appropriated $10,000 a year for three years for the same end. A special superintendent, Mr. Kirkland, with a staff of agents and assistants, was charged to preside over the execution of the work in America, and Mr. Howard, during the three years 1905, 1906 and 1907, was sent on a mission to Europe to seek for the parasites of the two species, visiting France, England, Italy, Germany, Austria, Hungary and Russia. He interested in his enterprise all of the official entomological bureaus, as well as the principal specialists, who promised him their help and active cooperation.

It is by hundreds of thousands that the nests of the brown-tail moth have been sent to Boston for two winters. It is in innumerable quantities that, during the months of June and July, caterpillars and chrysalids of the two species have been sent to both destinations. All these insects, upon their arrival in Boston, where they have been received by Mr. Kirkland, are sent to a laboratory specially constructed for this work. It is in the suburbs of a small village named Saugus, in a house which is constructed in the midst of woods infested by the caterpillars of the two species. Aside from the rooms devoted to research and rearing work, this house contains the local or resident assistant, who has charge of the work, and also the specialists who are sent by the bureau from Washington, at the time when the insects are appearing. The insects are reared in boxes constructed for that purpose, and somewhat like those employed by the State Board of Horticulture of California. To avoid the issuing of hyperparasites or of suspected species not existing in America, and accidentally mixed with the sendings, the cages are kept in closed rooms with double doors. They are arranged side by side in several longitudinal rows, and so abundantly that it is difficult to walk between them. When issued, the parasites are generally not set at once at liberty, but are allowed to breed in large outside cages.

To what practical results will these experiments conduct us? It is difficult to answer this question in a decisive way. The experiments have been in any case carried on under conditions most perfectly constituted to assure the success of the enterprise, and it was impossible to confide their execution to a savant of greater authority than the eminent director of the Bureau of Entomology, at Washington. Having a great number of parasites imported, an abundance of food which they find at their disposition, and a climate which they will encounter analogous to that of Europe, it does not appear doubtful that many species will acclimatize themselves, and as soon as acclimatized, they can not fail to strongly influence the balance of nature to the prejudice of the destructive species.

The time necessary for this movement of the see-saw may be long,

and it seems that one could hardly expect appreciable results before four or five years.

But what does this matter in any event? since we are trying to obtain a result of indefinite duration which will bring about exemption from the ruinous methods of destruction by insecticides and which will mark the end of a public calamity menacing the trees of the whole United States.

General Considerations and Conclusions

The exposition of facts we have presented in this memoir allows us to take stock of the importance gained during these recent years by the method of utilizing beneficial forms. It can not be denied that, practised in a judicious manner, it can render very great services, and the initiative of governments which have been encouraging large experiments destined to show its value, must be applauded. It would be bad taste indeed to criticize those who have brought about a check, for it is only by trying experiments that one can understand the conditions which may prevent success, and far from implying failure under such conditions, the experiments almost always teach a useful lesson.

Those accustomed to the experimental method and to laboratory research know well how the discovery of a new fact in science is made at the price of much groping, of misconceptions and of failures, and how these have to be conquered before the truth is learned. Is it reasonable, then, to suppose that it can be otherwise for these great experiments in economic entomology, of which we have just spoken? And if by forced circumstances those who are carrying them on can not be protected by the silence which the learned men of the laboratory enjoy, if the work which they are undertaking is exposed to distortion or exploitation by persons anxious to boast and to give out sensational information . . . these are circumstances which, to our eyes, can only add to their merit and to increase the rights which they have to our esteem.

If eulogy without reserve should be given to those who have taken part in this great movement in favor of the utilization of beneficial insects, we would have the right, on the other hand, to discuss the too-exclusive and too-optimistic conclusions to which some of the most fervent adherents of the method have been led.

It is in California above all, and in Australia, as we have said, that the theory has been formulated in the most absolute way. According to the claims of the State Board of Horticulture, of California, no insect is in its original home a pest of sufficient gravity to menace a crop in a serious way, because nature has always placed by its side a parasite capable of holding it in check. Each time that a new enemy reveals itself in a region and begins to undergo exaggerated multi-

plication, its orginal country should be searched for parasites living at its expense, and these should be procured and naturalized. This is, if I am not mistaken, the theory of Alex. Craw and his school.

In objection to this doctrine it should be urged that there exist insects which can be considered as veritable plagues to our crops, and which, however, are undoubtedly indigenous, such, in Europe, as the cockchafer, the apple anthonomus, the pyralis of the vine, the cochylis; and for America, the Colorado potato beetle, which would have ruined the culture of the potato in the United States if the use of Paris green had not been discovered.

But other stronger objections may be urged, if not against the principle of the theory, at least against its too great application and against the exclusive way in which it has been propounded. Admitting that it is incontestible that certain insects can become terrible plagues where they are introduced into a new country because they are not accompanied there by their natural enemies, it is manifestly going too far to hold that it is always to the absence of the natural enemies of an insect of exotic origin, taking the proportions of a plague, that it owes its virulence.

We know well, for example, that it is for entirely different causes, depending upon the nature of the affected plants, that the Phylloxera occasioned an unprecedented disaster in Europe; and it would have been taking a false step at the time of invasion of this insect to undertake long researches to procure its natural enemies.

An indigenous insect, which has been for a long time practically harmless, can become more dangerous and even arrive at the condition of a plague simply because man, by new crop conditions, in favoring the extension of some plants at the expense of others, and substituting for an extremely varied natural vegetation an immense supply of a single plant, has himself broken the equilibrium of nature and favored to a very large degree the multiplication of the insects that attack his privileged crop. It is in the same order of things that an insect living upon a wild plant becomes adapted to a cultivated plant, and multiplies excessively at the expense of the cultivated plant whose conditions are particularly favorable to its nutrition. One of the most striking examples of this phenomenon is the case of the Colorado potato beetle, of which we have already spoken. This insect, originally from the Rocky Mountains, lived solely upon wild Solanum, but about 1855 it invaded the potato fields which began to be cultivated in its country, and then gradually spread into all of the potato fields of the United States and Canada, causing terrible damage.

Finally, it is not necessary to believe any longer that all exotic enemies, whose appearance is signalized by extreme virulence, will bring disaster unless their natural enemies are introduced. It is

rational to believe, on the contrary, that at the end of a longer or shorter period there will be brought about an accommodation between the plants and their enemies, analogous to that which is produced between animals and bacterial, trypanosome or piroplasmic diseases. It is well demonstrated that certain insects like the scale insects inoculate in the sap certain toxic products, and it happens that varieties of plants that have never been attacked before by these insects are at first peculiarly subject to their action, then at the end of a longer or shorter time they begin to acquire a relative immunity—an immunity acquired in a way quite different from the formation of anti-toxins may be conceived, that is to say, an immunity attributable to many defensive adaptations of the plant, consisting in modifications of the plant tissue and tending either to render the attack of the insect more difficult, or to diminish the quantity of food which it can get, or again to render the lesions which it produces less dangerous.

If, for example, the San Jose scale is less injurious in its native country, can it be said that this is the case only because of the parasites which hold it in check? Are there not serious reasons for admitting that the trees of this country may be formed of varieties adapted to this insect, capable of resisting it?

Finally, we should also take into consideration the fact that if, during the first years following its introduction, an injurious species of exotic origin can multiply freely without any parasite to interrupt its multiplication, there often comes a time sooner or later when the parasites of a country living at the expense of the indigenous forms most nearly related to the exotic species progressively adapt themselves to the latter and end in limiting its propagation. This cause, added to the progressive adaptation of plants, appears to be bringing about the actual diminution of the virulence of the San Jose scale in America.

It results from what precedes that in the problem with which we are occupying ourselves the factors are multiple, and that it will be a great mistake to consider one or the other and not all.

If, because of the too absolute manner in which it has been formulated, the theory of the utilization of beneficial insects must surrender somewhat, it is necessary also to point out the errors and the exaggerations to which it has given rise in practise, for they give rise to excessive hopes, provoke serious disillusions, and are a discredit to the whole method.

In the first place, a grave fault resulting from an excessive confidence in the action of parasites consists in advising the suppression of insecticides in a region where it is desired to acclimatize the beneficial species. In the great majority of cases, at least in regions where insecticides are employed with success to hold a crop enemy in check, the desire to acclimatize a beneficial species should not cause the gen-

eral use of sprays to be stopped. The two methods are not incompatible, for in a given region it is very rare that you can regularly spray all of the trees. This one, or others, will not be treated, and the ladybirds and other useful insects will therefore have a free field to carry on their beneficial work, and centers from which they can be dispersed will be created.

One of the greatest dangers in introductions consists of the possibility of introducing into a region an animal which considered as useful in its original home, is capable of becoming absolutely injurious in the new country into which it is introduced, on account of the conditions of the environment which it encounters. The examples of the sparrow imported from Europe into America and Australia, of the mongoose introduced from the East Indies into the West Indies, of the rabbit imported from Europe into Australia, are too well known to be described. It has been stated that no danger of this sort exists in such cases as these, since parasitic insects of other insects can live only at the expense of these last, and it is the same with predaceous insects. There is no doubt of this, but there exists another danger of a direct character in the importation of the insects which are desired for acclimatization, and that is the danger of importing at the same time either injurious insects sent along as food, or hyperparasites which can prevent the propagation of the useful insects and which becoming acclimatized themselves, endanger even certain useful indigenous species.

It is very easy to take the necessary precautions so that the insects which serve as food during the journey should present no danger, and it will suffice to make sure that they belong to a species existing already in the region where they are to be acclimatized.

The history of the naturalization of *Icerya purchasi* in Florida shows us that the method of utilization of beneficial insects, practised by incompetent people, may have sad consequences.

As to the danger from hyperparasites, while it is apparently not so serious as the preceding, it is, on the other hand, much more difficult to avoid. Preliminary rearings are necessary before the beneficial species are definitely set at liberty, and all precautions are necessary after the issuing to separate the primary parasites from the hyperparasites. It is for this reason that the application of the method of the utilization of beneficial insects, in order to render all the services which are expected of it, should be carried on indispensably and exclusively by learned men, especially informed concerning insects and their reciprocal and biological relations.

We have shown in this memoir about all that can be drawn from the utilization of predatory and parasitic insects in the struggle against enemies of crops. One conclusion may be drawn also from this study,

and that is that one can not count upon beneficial forms as a substitute for the methods of destruction commonly used in applied entomology. Their rôle does not consist of exterminating a species, but of maintaining a natural equilibrium, or of reestablishing it when it has been disturbed by human intervention. In such cases, their action can make itself felt in a more or less prompt way. It may happen that, immediately after having been imported into a country, they stop with an extraordinary rapidity the plague which they have been brought to combat. This was the case with *Novius cardinalis,* in California, and in different countries. It was also the case for *Crypotolæmus montrouzieri,* which made very rapid spread in Hawaii. It must be stated, nevertheless, that this is rather exceptional and that, in general, a number of years are required—the number varying according to the species and to the circumstances under which it is brought—before it can be completely naturalized in a given country, and before, thanks to its spread, it brings about a sufficient retardation of the multiplication of the plant-feeding species for which it is imported, to reduce it from the condition of a scourge to that of a supportable species.

The services that parasites and predaceous species render are sufficiently great so that there is no necessity for exaggerating them.

Far from lulling ourselves with illusions, we should keep on the watch and foresee the dangers with which other injurious species menace us, such as *Icerya purchasi,* which may any day invade Provence or Algeria on plants imported from Portugal and Italy.

There is no doubt that, however great may be the efficaciousness of a ladybird, like *Novius cardinalis,* it will be still better not to have the enemy at all than to be obliged to fight it by the intervention of its natural foe. We do not know that *Novius cardinalis* will with us develop with the success which marked its spread in California, in Portugal, and in Italy. We are ignorant whether the climatic influences or some parasite, recently adapted to this new strange host, will not limit its propagation and diminish its beneficial action. Finally, other plagues than *Icerya* menace us, and it is unfortunately certain that not all of these may be mastered by the equivalent of *Novius cardinalis.*

Confidence in the assistance which we can get occasionally from parasites and predaceous insects should not make us lose all prudence nor prevent us from seeking a guard against the perils which surround us, in organizing at our large ports an inspection and disinfection service like those which have been started at foreign ports, notably Hamburg, and in a general way taking every measure possible to protect our crops.

OF THE SOIL OF THE EARTH

By SPENCER TROTTER
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ONCE upon a time—certainly more than two hundred years ago and no man knows how long a time before—an aboriginal folk fished in the waters of the West Fork of Brandywine. The remains of an old breastwork of stones point to the former site of a dam, connected probably with a rude sort of weir. Such is the tradition handed down through several generations in the family of an alien occupant of the land. This occupant and his descendants to the present time have never permitted the ancient work to be disturbed, a rare and kindly virtue in these days of scant sentiment. Only the unhindered stream has worked its will. Not far from this dam, on a low rise of land overlooking the valley, stands a scattered group of trees—white oak and shellbark hickory—and here, again tradition has it, this aboriginal folk buried its dead. Certain it is that the alien occupant, though he ploughed deeply all about, likewise left this spot sacred to the hand of time. The site is not marked by any tumuli; only the level ground appears a trifle more grassy in some places, more springy under the foot, which lends color to the tradition of long-forgotten graves.

It was beyond a question that somewhere in this ground the mortal traces of a man lay scattered—hidden as completely as in that prior time of his being when as yet there was none of them. Deep in some maternal tissue there had once been that marvelous gathering together of elements—that ever-repeated miracle of the fashioning of a form of life. Where no light was there was yet the molding of a structure that in the days to come would be responsive to the light and to every play of color; a structure that would hold wonderful pictures of land and sea and sky. Where no sound was there was yet the molding of another structure that would come to know the sympathetic voice, the springtime song of birds, the multitudinous sounds of the forest, the droning cadence of streams. In the depths of this nebulous man another structure was being spun out of the life stuff, one that would come to hold all that the sights and the sounds had to tell, that would interpret their meanings, that would come to feel and to know, to remember and to wonder. And yet in this dark fountain-head of being there was no hint of such future possibilities. All through this formative man the delicate threads of life were spun between the central

brain and its outposts that in the end he might know himself and all that went about him. Bit by bit bone and muscle, ligament and sinew, were pieced together—strange artifices to do the brain's bidding. The heart began as a throbbing pool of blood, the red current of which found its devious way to every nook and cranny of the rapidly growing form. Long before the possibility of air ever reaching into these depths of dawning life the lungs were fashioned, and the mouth and stomach were prophecies of the hunger to come.

Each particle of life matter that went into the building of this man was indelibly stamped with the impress of inheritance. He was fashioned after his kind. When he finally appeared among his people and as he grew into manhood the bronze color of his skin, the straight black hair, the dark iris, the long head with its high arched cheeks, betokened the stock from which he sprang. His ways and his speech were those of his ancestors. The more remote of these ancestors had come from a hyperborean land at a time far back in the dim, unrecorded lapse of millennia beyond the reach of tradition—a forgotten dream period like that before birth. These ancient men without doubt saw the mastodon in the flesh, as our cave-dwelling ancestors over the seas beheld the mammoth. Successive generations of them may have witnessed the floods of the melting ice-sheet and the changing features of lake and river basins. A later horde, within the period of tradition, crossed the River of Fish (Namæsi Sipu), fought and drove out an ancient people—the Alligewi—who dwelt in the forest land to the east of the great river and whose curious earthworks remain to this day, and finally reached the place at the rising of the sun, beyond the mountains (Alleghany), by the shores of the Great Lake of Salt-water. Such is the meager thread of this man's race history.

Through the lapse of time with its shifting scenes the never-ending drama of the generations of men goes on—birth, and the span of life, and death. One indestructible thread is woven into this tissue of humanity—the thread of inheritance that reaches back, like the strands of a cable, into abysmal depths. This subtle thread of inheritance that runs through the generations had made this man what he was and had cast him into his time and place. And the end of it all is an unknown grave, as it is with Homer and Cæsar, and the innumerable host of men, small and great, that have ever lived.

In the waning light of a November afternoon I found the man where he had lain these two hundred years or more imbedded deep in the soil of the earth. The sockets in which the light of life once gleamed, the cavernous nares through which the smells of young April poured into the brain; the bony ear canals that once rang to the rhythm of the stream; the mouth place resonant with its strange speech—all plugged solid with the clay. The very bones themselves had taken on

the earthy hue and texture, crumbling into fine dust. A few enduring bits of handiwork—quartz pebbles which had been laboriously bored through for a bead string, a brass finger-ring, a curious piece of shell—were scattered about in the clay; simple things that seemed to mock the less enduring framework of life.

The one haunting thought, after the emotional and scientific elements of the mind had satisfied themselves, was that this man, this aborigine, whosoever he may have been in the flesh, had resolved into nature. There was no victory about this sepulture. The earth had simply taken this man again to herself, and as she had molded him from her clay and built him up out of her breast milk and her maize and beans and the flesh of her fish and fowl, so now she was gently and leisurely scattering the molecules that her magic hand had once so artfully put together. Here then, methinks, is the plain tale of all men.

The sun sank behind the Brandywine hills; the light of the western sky faded and with it the outline and color of the landscape. The first few stars twinkled dimly overhead. The filling crescent of the moon hung low in the darkling west and passed out of sight. The Dipper turned slowly across the northern arc. The dawn light of a new day came into the east. It was the never-ending change of the eternal background. Countless generations of men had passed, their very existence forgotten—blotted out in the lapse of time—and still the everlasting shift from day to night, from night to day, went ceaselessly on. Of what account was this man or all the millions of men that had lived only to be forgotten—lost in the soil of the earth?

As the thread of inheritance is seemingly indestructible so far as the race of men is concerned, there appears still another manifestation of immortality, of a purely individual character, which appeals to every man as an element of his being that must outlast the things of time. Just what this is has never been vouchsafed to any man to know. It is the eternal riddle of life, the hopeless tangle of all mythology and philosophy throughout the ages. Mankind has ever found itself in a world of material facts and elemental forces the manifestations of which have revealed a vast environment of the unknown. What a man calls his soul is the recognition of this unknown which lies beyond the reach of his senses. The mind has explored a half-way region—a region of principles and forces—and has analyzed these with some degree of surety. Beyond this, on the boundless ocean of infinity, the chart and compass of the mind are of no avail. Men have framed theories of this outer realm far more crude and improbable than any notion entertained of the outer geography of the Odyssey and they have peopled it with beings quite as improbable as those encountered by the adventurous Ithacan. More than this, mankind in every age and

in every state of society holds to the belief, more or less crude in its conception, that at the dissolution of the body the individual ego, soul, elusive psyche, will burst through the barrier of the material and pass into the limitless realm of the unknown.

Through the medium of his sense organs a man perceives the material portion of his environment, at least that part of it that can affect these nervous structures. The mind, however, reaches out beyond the frontiers of sense and has divined the existence of those supreme elemental forces that mold and shape the material universe. But not a hint comes from these efforts of mind and sense as to the great underlying question of the unknown. On this question, I take it, the primitive pagan is as enlightened as the most accomplished philosopher.

Touching the fact that a man's recognition of the unknown comes through the amplitude of his being, it becomes a matter of no small moment that this being is a state of living within the domain of a material environment. Whatever is discerned of the unknown environment can not come else than through natural means, for man is not greater than nature. Moreover the unknown is not a supernatural realm, nor is what man calls the soul a supernatural portion of his being. Both alike are indeterminable elements within the sphere of natural law and are supernatural only so far as they are indeterminable and represent an unknown quantity in our comprehension of the universe. Seeing that knowledge can not accomplish this end of knowing the unknowable, it remains for a man to know himself as a part of nature, which, so far as may be discerned, is working toward some vast purpose. It is surely no part of the scheme for him to blind himself with false ideas and vain imaginings about a hereafter. His work is to live the life of the great animal type into which he has developed, uplifted by all that comes to him through his exalted brain structure.

Research into the nature of things, which characterizes the modern scientific attitude of mind, is unquestionably a means toward a fuller appreciation of the conditions of existence. This does not necessarily imply, however, that the pagan's philosophy of life is altogether a failure. There is a warmth and vitality in the pagan view of nature which the scientific mind has never attained. The poet comes nearer to this, since the poet and the pagan alike personify the forces of nature and idealize the facts of life and environment. And it is on this idealization of the facts that men build their joy in life. This man of the Brandywine knew nothing of molecules or of the ultra-violet ray, yet he surely knew the joy of the opening spring. He was not versed in the geological history of his locality, but the hills and the stream were part of his very life and he read their story in his own way. The voices of the forest spoke to him in a language unknown to men

of a less wild strain of blood. There was a personality like unto himself in each beast, bird and fish that he knew; a *genius loci* in every waterfall and mountain glen. The forces of nature were personal elements in his philosophy. He lived, this man of the long-forgotten past, as all men live—getting his food, begetting his kind, loving, hating, fighting, rejoicing in the coming of the spring, pleased with his own person and its adornment, repeating the tales of his forefathers about the fire—then vanishing into the all-containing soil of the earth whence he came.

What man, once quickened by the spirit of the earth and touched by its thousand sweet influences, would ever think of resigning this mortal inheritance, with all its certainty of dissolution, for an immortality in some unknown, untried sphere of existence? The perennially hopeful day; the charm of sex; the friendliness of fellowship; the mating of man and woman; the birth and nurture of children; the buffet of the elements; the warmth and glow of fire; the delight of working muscles; memory-haunting smells; food and drink; labor and rest; the night and sleep—these are man's heritage and joy.

If the old pagan spirit still dwells in the hearts of men it surely makes for the best and sweetest that life holds. In this spirit a man may come to regard the dissolution of his body with some degree of complacency, knowing that his mortal parts will again become incorporate with the soil of the earth, and the grass, and the all-sustaining air—things which entered into his being through all the days of his life—and yet trusting that the best of him—the part that found joy in living—will still find joy, somehow and somewhere, in the realm of beneficent nature.

THE CONSERVATION OF THE GREAT MARINE VERTEBRATES: IMMINENT DESTRUCTION OF THE WEALTH OF THE SEAS

By G. R. WIELAND, Ph.D.

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THE rapidity with which our large wild animals are being destroyed at the present time is scarcely realized, to say nothing of the threatened introduction of a noiseless gun. Because this or that species is usually considered by itself, it is not generally noted that in the aggregate there is scarcely a single feral form large enough to attract the bullet of the hunter but is foredoomed to speedy extermination if a public sentiment mighty to save is not soon aroused; and such sentiment must cross and recross political boundaries, must be world-wide, to be wholly effective.

Much has been said about the preservation of various birds and land mammals; but with the exception of the seal, the passing of the great animals of the sea provokes little comment. Indeed, their protection or conservation is commonly deemed impossible or not worth the while, it being invariably overlooked that not a single great animal of the sea, unless of extreme rarity like some of the gigantic cuttlefishes, is without a large economic value, and thus always sooner or later the object of an exterminating hunt. Much less is the zoologic value considered—that intrinsic side which passes far beyond more obvious utility into the domain of the philosophic, and lends to sea and land a mighty charm.

Contrariwise, students of animal history and distribution, and more especially those who go back and study the fossil record as well, can not fail to observe with alarm the unremitting warfare against all the animal kind, that, extending far into the prehistoric period to the great land turtles and moas, has with the exploration of the remote places of the earth and the arming of every savage tribe with modern weapons, become a heedless *debacle*. It is therefore simply in the performance of a plain every-day duty that in recent annual mid-winter meetings of various scientific societies there has been brought forward for discussion, on a broad basis, the question of animal conservation on a large scale. We may especially cite the resolution passed unanimously by the American Society of Vertebrate Paleontologists at New Haven, as follows:

Resolved, That the American Society of Vertebrate Paleontologists will aid in any way practicable those measures legislative, international and local which will prevent the now imminent extermination of the great marine vertebrates, especially the cetaceans and manatees, seals, green and other turtles on the coasts of the United States, or on the high seas.

This resolution was also adopted as its own by the American Association for the Advancement of Science at its Chicago meeting, and very similar action has been taken by the New York Zoological Society looking to needed action by congress. Many evidences of a world-wide interest are at hand.

The Thousand-year Hunt of the Whales

The first of the great cetaceans to be hunted, was the Biscayan whale, *Balæna glacialis*. Its capture was begun in the ninth century by the Bisques and soon taken up by others. Following extermination in the Gascoigne Bay, the hunt was slowly pushed northward to Finland and Iceland, and along the western Atlantic; it being even possible that whalers visited the Newfoundland shores long previous to the discoveries of Columbus. The relentless warfare to which the Biscayan whale was subjected for hundreds of years culminated in the sixteenth century and only stopped short of total extinction through the extension of the fisheries to the far north and discovery of the greater value of the Greenland whale, *Balæna mysticetus*.

The capture of the latter began in 1612 in the open waters between Spitzbergen and Greenland, and soon extended to Davis Strait and Baffin Bay. After two hundred years of unceasing pursuit this whale was driven to the remote places of the Arctic Ocean, and is now so nearly extinct that its recovery in numbers is doubtful. It may be too late to save this form; although from 1669 to 1778 it yielded to 14,167 Dutch vessels 57,590 catches worth $16,000,000 net. But this is only one of the many killings of the proverbial goose that laid the golden eggs, and a cruel enough one too. Scoresby says, in speaking of this timid whale of strictly arctic range, that it shows an affection for its young which "would do honor to the superior intelligence of human beings"; but being a trader as well as observer he adds that "the value of the prize . . . can not be sacrificed to the feelings of compassion!"

After the virtual extermination of these two more valuable species the merciless hunt was diverted to the much wilder finback whale, *Balænoptera physalis*, now in turn with still other forms destined to extinction if restrictive measures are not soon taken. For in these days of steam, and electric light that robs the long arctic night of its terrors, the whale chase goes on very fast. The shot harpoon,[1] the

[1] Invented by Sven Foyn about 1870, by which time, owing to wildness and scarcity of the whales, the older methods of capture were no longer capable of returning a profit. Foyn was at first a sealer.

most extraordinary weapon ever used by man in his pursuit of helpless animals, is doing its deadly work at a rate that does not permit delay.

No effective measure has yet been taken; although man has actually made his first pause in the brutal butchery and reckless waste of the whale kind, begun a thousand years ago, and now nearing an end hastened in geometric proportion by modern invention.

The capture of the finback and other whales is indeed forbidden in the Norwegian fjords, but this is of little avail; for, unfortunately, the whales visiting the Scandinavian coast to calve and feed their young make a round into the far northern waters about the Bear Island and Spitzbergen, and are there slaughtered just as inevitably. When I was at the Bear Island whaling establishment early in July last I was informed that up to that time the season's catch already numbered forty-seven; and the evidence on every hand, the several thousand barrels of oil on the hillside, the skeleton-lined shore, the thousands of carrion-eating birds, and the trying-out works that sent up an odor that literally smelled to heaven as it floated away for miles over mountain, valley and snow field—all these told the story of short-sighted human greed better than records.

This reckless arctic hunt is now largely confined to the finback, to *Balænoptera borealis,* to the gigantic blue whale, *Balænopteris musculus,* and to *Megaptera longimana.* It is a bloody hunt, occurring when the females, which show throughout an extraordinary affection, are suckling their young.

The most recently attacked form is the bottle-nose, *Hyperoodon rostratus;* and just twenty-seven years have brought this superb gregarious animal to the verge of extinction; for although worth but a few hundred dollars each, this species is easy to catch. Unlike the fierce and wary "*cachalot,*" its wondering curiosity and lack of fear makes it easy prey.

For the greater part, however, the whale butchery is, for a second time, being transferred to the Antarctic, where, after an interim of fifty years, whales are again more plentiful, showing very conclusively the need of exact study of the habits of the whale and an international police patrol. So far as we are monetarily concerned, it may be stated that the whaling industry of the United States, north and south, from 1835 to the wane of the fisheries about 1872, yielded oil and bone worth $272,000,000; this vast sum being the net from 19,943 voyages with a capture of 300,000 whales.

The total capture of all the species of whale mentioned above may well fall short of 1,000,000 individuals—certainly a limited number when we consider a hunt that has occupied the maritime nations of the globe for quite 1,000 years, and a number, moreover, that warns us how very liable to extinction are all enormous and highly specialized mam-

mals. Evidently the values destroyed in the unreasoning hunt must already be several times as great as the market price of the product secured, to say nothing of the future. It is apparent enough that even if we deny to animals the right to live that Professor Nathorst has so justly and so eloquently maintained they have, the reduction of our problem to the sordid standard demands immediate action. Certainly no one need be reminded that it has taken nature millions of years to evolve the whales, and that it is unlikely that the feat can be again duplicated on this planet.

The great destruction of the whales is, as we see, then, mainly modern; the first six or seven hundred years of hunting previous to the use of swift launches were not so noticeably destructive. Perhaps the manner in which large animal species living under strenuous conditions and necessarily breeding slowly are so swiftly destroyed in modern times can be understood better in the case of a land form like the musk ox, to which I may briefly advert. Half sheep, half ox, this curiously interesting animal, yielding in quantity a strong under wool with a texture as fine as silk, is confined solely to the treeless arctic wastes of North America and the islands to the north; its habitat originally extended from Hudson Bay westerly to the Mackenzie River, and all through Baffin Land, and Ellesmere Land to northernmost Greenland. Though the musk ox, despite this wide range, is now becoming exceedingly scarce. Cut off by the white hunter everywhere to the south, the Eskimo of the far north, always hard on the musk ox, have at last obtained guns and are now killing the northern remnants of the original herd. Thus is this hapless denizen of the most inhospitable regions of the earth being ground between the upper and nether millstone.

As such a process must have a speedy end, it is greatly to be hoped that the musk ox can be introduced into Alaska, and that the Canadian and United States governments may soon take this subject up conjointly. It is most unfortunate that the recent Swedish attempt to introduce musk oxen into Jämtland, southern Lapland, has failed owing to local parasitic enemies.

Destruction of Our Sea Turtles

Taking up another group of great sea animals; no chapter in the story of destruction is quite so harrowing as that of the sea turtles of the southern coasts and islands of the United States—the more so because it is not only the original supply that has been cut off, but because there is not the least doubt but that the turtles can with slight expense be increased vastly beyond any numbers ever observed in purely natural environments.

The problem of conserving and increasing the plant-eating green turtle and the animal-eating hawksbill, which yields the tortoise shell

of commerce, should be definitely taken up, and solved. The original numbers of these forms in the natural state were always limited by the helplessness of the young when first hatched. With a shell at first very soft, great numbers are eaten by the shore birds of prey before even reaching the comparative safety of the water after floundering out of the sand where the eggs were laid. And once in the water the young are still for a time the prey of sharks, so that of the hundred or more that emerge from a single hatching a very few survive these early dangers to reach adult size. This helplessness may, however, be readily tided over by only the slightest protection, as the young grow very rapidly, and the shell soon thickens. If all shores where the green and hawksbill turtles lay their eggs were guarded by law enforced, and the young safely piloted to the water and perhaps fed for a few times only, it is evident, remembering the unvarying habit of the females to return to the same shores to lay their eggs, that the great pasturing and foraging grounds of our southern waters could be made to teem with these turtles. Audubon gives a vivid account of the Florida "turtlers" and the abundance of the turtles in his day; though these original numbers can doubtless be increased twentyfold.

Yet it has come to pass that the United States Bureau of Fisheries has not during several years of effort been able to secure any eggs of the green turtle whatever on our shores. Nor will it be otherwise with the less palatable loggerhead in a very few years, if as at present, even the employees of the Coast Service, part of whose duties it should certainly be to protect these animals, continue as now to be the chief agents of their destruction. Even on the Dry Tortugas within shadow of the Marine Laboratory of the Carnegie Institution the lighthouse keeper whiles away the night searching up and down the long white sandy beach for turtles; and save in a fog, every time a female turtle flounders helplessly on to the beach to lay her eggs our friend of the lighthouse signals with a warning horn to the "beach combers" and "conchs" who rush up and despatch the egg-bearing female. These "conchs," are indeed an evolving type of very hungry beachers who, now that game is scarce, "*close*" on everything from a wrecked schooner to a stranded turtle or whale.

Protection of All the Great Marine Vertebrates is Feasible

Certainly the "beacher," the "conch" and the "sea wolf" are as interesting as the animals they destroy, and within certain very specific limits may deserve perpetuation! Meantime, for the sake of the preservation of both, as well as the superior rights of those dwelling inland—the greater number interested in the question of the eminent domain of the sea—it is needed to quickly demonstrate the fact that the world will not tolerate needless slaughter of its anciently evolved

animals, least of all when this incurs values *incalculably* greater *than those represented by the seals* alone.

All phases of this question which can be handled locally, and such are the more urgent phases, should be so handled by the proper bureaus, already in existence, backed by unmistakably knowing public sentiment. Sequentially the system of international safeguarding should be extended and perfected—the same system that has been already invoked for the seals, by reason of the fact that they yield that woman's garment —the seal-skin cloak. Only when all the sea animals are considered will this system ever be effective in the case of any single species; and somewhat setting aside altruism, it does seem strange that the immense values of the whales and turtles should have been so persistently overlooked. On the other hand, a very great altruistic value is also involved. For all international movements leading to the reasonable use of naval equipment in patrolling all the seas for the sake of common and world-wide interests and sympathies—those causes at once humane and wealth-conserving, must thrice bless.

It is, then, we must emphatically insist, neither Utopian nor impractical to attempt and speedily carry out the measures required for the preservation not only of land animals, but of all our great animals of the sea. The only element of doubt is whether the volume of sentiment can soon enough make itself felt—in short, whether the race has reached the required culture stage in time. Science has laid low the fallacious theory of fabulous gold dissolved in the waters of the seas, and we no longer heed this phantom of wealth which has deluded credulous minds quite since the days of alchemy. Nevertheless, this old belief may yet find a certain large measure of prophetic fulfillment if man can overcome his habits of wanton destruction before our great marine animals are extinct and the possibility of their preservation on this planet gone forever.

To be practical, every zoological text-book should have its chapter on the conservation of the animals of the land and sea. None should be forgotten, as many must inevitably be if the subject of conservation is not taken up in its broadest phases and based on first principles in order that specific applications may be both general and intelligent. And such teaching and applications, at once interesting, useful and elevating, should make their way into every district school. It may well be doubted if the human kind will ever be merciful to itself without being first merciful to the beast kind. For use and domestication do not constitute cruelty, since in natural environments the end of the individual is always violent—that is the weak are captured by the hunting animals, and the lion starves when no longer able to hunt. Conversely, to exterminate the forms of the sea and land is repulsive. What a degrading, miserable story is that of the hunt of the sea otter.

THE WHITER PITTSBURGH

By JOHN F. CARGILL
PITTSBURGH, PA.

IT has very happily been said that the location of the city of Pittsburgh was decided in the Carboniferous age of our planet. Equally true it is that, uncounted ages before the primal granite was clothed in verdure which "the creeping centuries" drew from surrounding air, some happening in far-away nebular space—some law of gravitation or propulsion determined the soft coal deposits, and the three branching rivers of later age. These things influenced and prearranged the site of the Iron City. If the widest range were given to imagination, perhaps it might be argued, too, that the all-enfolding laws shaped even the course of modern industry—declaring what manner of people should become the city's builders. But it is not the purpose of this article to raise any question of law *versus* foreordination.

The early settlers in the Pittsburgh district were largely composed of Scotch-Irish; a stock rugged and honest, that has, individually and collectively, assisted in the making of more world history within the past three hundred years than any nationality has ever done within a similar period. The unleavened Scotch-Irishman can hardly be described as of fascinating or lovable personality; but empires have never been founded or perpetuated by qualities sweetly lovable. Strength and determination are the essentials; and "rugged and honest" is a fair designation. Many another people might well covet one so good.

He has usually been punctilious in his dealings, reliable and moral: a considerate husband and father, religious, Calvinistic, opinionated, self-sufficient, blunt and austere. He is little interested in literature, or in science except in so far as it might contribute to his immediate business interests. The Bible is, in the main, he thinks, sufficient for literature and the conduct of life. (The reference is not so much to the comparatively modified and composite man of to-day as to the generation that is passing.) In character and temperament he is radically different from the New Englanders who settled some of our other bustling cities to the north and west; but no man is in position to say that, so far as material results are concerned, the Pittsburgher has not availed himself to the utmost of his opportunities.

Before the war of the rebellion, Pittsburgh was of comparatively little consequence. There was a town here, which had called itself a city for more than fifty years. Situated at the junction of three rivers, the waterways furnished the means of traffic. But there was

little business; no capital invested from the outside; none of the present-day commercial enterprise. Every small manufacturer was a workman, and furnished his own capital. Such statistics as we have of the decade before the war show that all combined the little furnaces and factories used somewhat more than three hundred thousand tons of coal per annum. In 1906 forty-six million tons were mined in the Pittsburgh district. Farming and matters relating to river traffic were the greater industries, and Pittsburgh was the market and outfitting emporium west of the Alleghenies.

When at length a little charcoal iron began to be produced, the sturdy artisans of Pittsburgh worked some of it up into articles such as plows, axes, saws, scythes and other farm implements; locks, scales and malleable iron castings. But the Pittsburgher did not reach out after business; he scarcely even asked for it; all of which is in conformity with the Scotch-Irish principle of stubbornness. He did not advertise, nor send out salesmen. It has been said that not a traveling salesman was sent out of Pittsburgh before the war. Whereas the Yankee business man of other western towns went after trade, the Pittsburgher's attitude was that of confident indifferentism. "This is the head of navigation," he would say—"everything has got to come here, sooner or later." And he was right. Whether he builded better than he knew, we can not say; but events have proved that his industrial fortress was impregnable.

It was during the years of the war, and the period immediately subsequent, that Pittsburgh "found herself." The first oil discovery was made just prior to the actual breach between the north and south; and the production of oil, added to the other resources of the region, gave a new impulse to the industrial situation. The terrible years from 1860 to 1865 stimulated rather than depressed business conditions in Pittsburgh; since the needs of the War Department, of outfitting, furnishing of arms and armament, building of river craft and gunboats, and the point of vantage that was offered for the transfer and transportation of troops and supplies, were tremendous factors.

The things that have made for the development of Pittsburgh in the last generation have been set forth and printed and distributed the country over, and translated into all the languages of the globe. To try to enumerate them would involve a burdensome task, unnecessary to the present article; and only a few leading figures may be given, merely to suggest what is now being done.

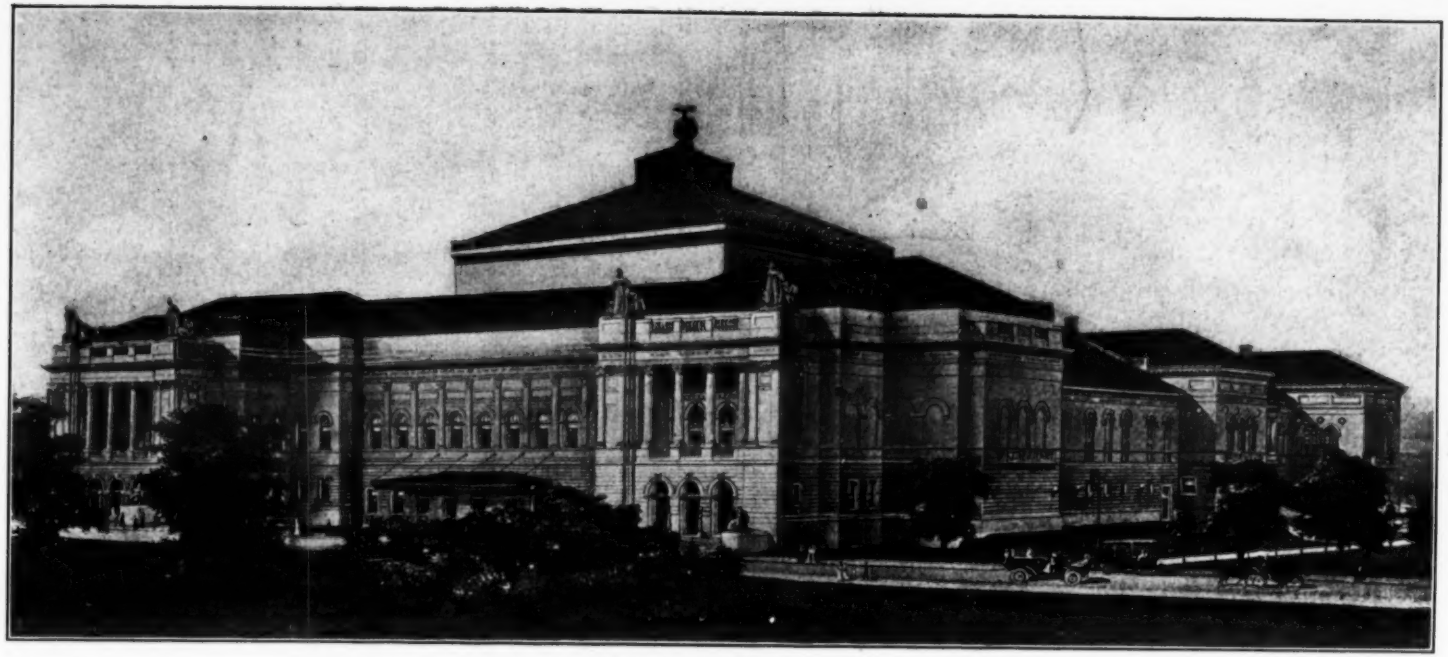
The coal production of 1906 has been stated at 46,000,000 tons; the figures for 1907 being not yet accessible. The traffic tonnage, by rail and river for the same period was 122,000,000 tons; 12,000,000 tons having descended the Ohio River from Pittsburgh. The traction cars carried during the year 200,000,000 people. The total bank deposits at the close of the year were over $340,000,000. The real

estate sales were over $70,000,000. The present population of Greater Pittsburgh (Pittsburgh and Allegheny) is conservatively placed at over 550,000.

The figures of the total output of furnaces, mills and factories are so enormous as almost to set present estimates at defiance. Such a wonderful era of prosperity, such wonderful opportunities for swift acquisition of riches have never been witnessed in the world before; and certain resulting effects have been witnessed which might have been foreseen. That these effects are not at all surprising—that they are not widely prevalent, and might reasonably have been expected to be much greater, can be easily shown. The habit appears to have become chronic among professional paragraphers to assume a necessary decay of manhood as a resultant of accumulated wealth. But Goldsmith would have been the first to declare himself merely a licensed poet; that he molded no prophetic verse.

In view of the city's far-reaching reputation for grime and unloveliness, it would seem well to mention a fact that is cause for general surprise to visitors, namely, the beautifying of streets and parks, and the construction of fine driveways in the suburbs. The natural beauty of western Pennsylvania can only be realized when one leaves the business part of the city and plunges into the districts adjacent, where conditions are found that suggest what must have existed before man's transforming had converted the earth to his own uses. It is doubtful whether any community, east or west, has done so much in so short a time, to make the surrounding country accessible. In various directions about Pittsburgh fine, hard, smooth macadam roads extend for many miles. Even roundabout some of the suburban towns, as Sewickley, twelve miles down the Ohio, one can travel by carriage or automobile over excellent roads for long distances through a region showing diversified scenery of great beauty.

Fine parks were never more essential anywhere than in Pittsburgh; and it is mainly owing to the munificent generosity of Mrs. Mary E. Schenley, whose gifts to the city amount to about ten million dollars, that the great need has been supplied. Schenley Park is situated accessibly, and consists of seven hundred and fifty acres. The topography lends itself admirably to landscape gardening. Nobler or finer trees can not be found anywhere, and the bold hills, small streams and deep valleys have been made use of in an artistic way. Highland Park lies on the hills overlooking the Allegheny River, in the northeast environs of the city. The carrying out of the artist's plans has caused the construction of winding shady drives; and the features include an artificial body of water known as Lake Carnegie. Reservoirs which supply the eastern division of the city with water are located



THE CARNEGIE INSTITUTE.

on the high hills adjacent. The total area of all of the parks is over nine hundred acres.

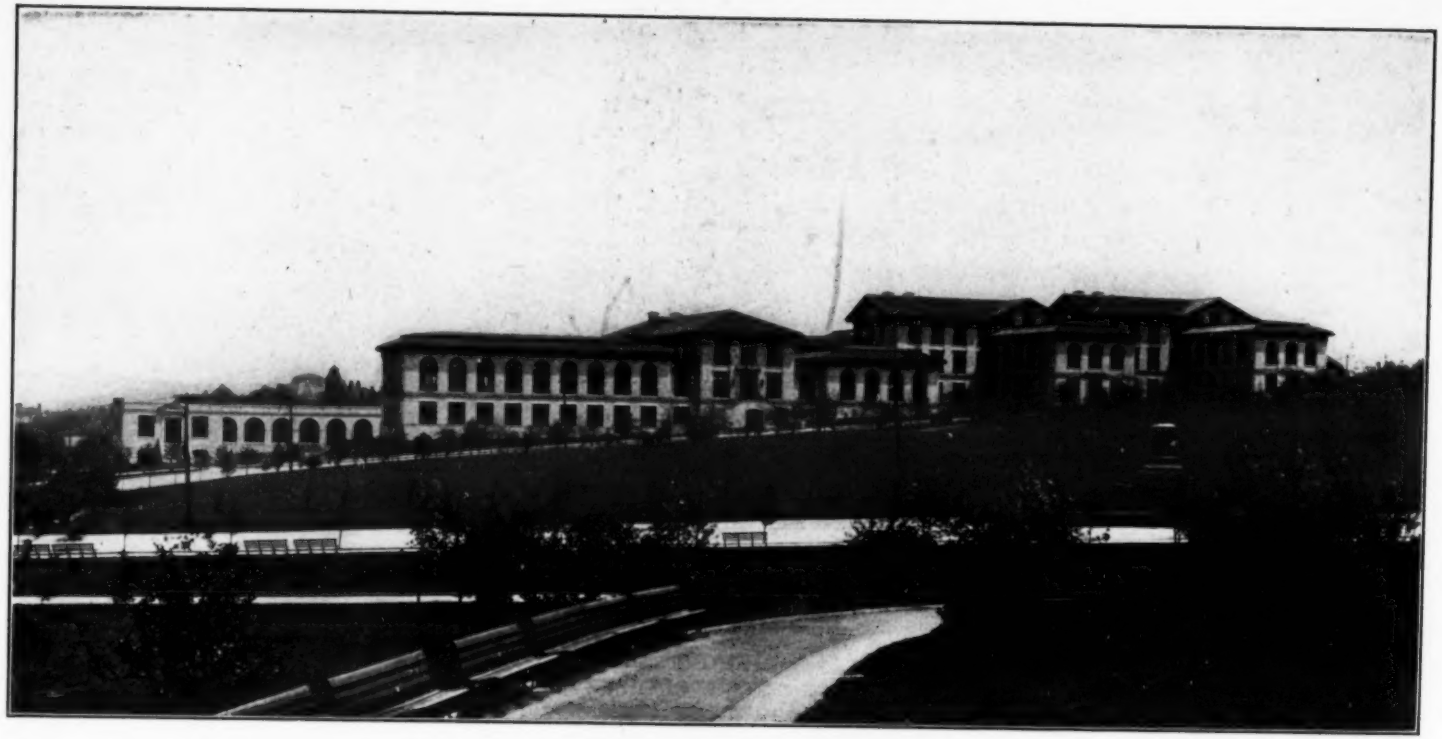
The city that leads the world in iron manufacture must inevitably be a smoky city. For a period beginning in the early eighties, when natural gas was first applied to manufacturing on a considerable scale, the diminished use of coal led to brighter and clearer conditions. But the industrial growth of Pittsburgh has been such that the supply of gas soon came to be inadequate. Gas is still used as an auxiliary fuel, but the percentage of soft coal is growing relatively larger year by year. So far as the iron furnaces are concerned, it is hardly to be expected that much relief from smoke is likely to be had while coal remains as plentiful and cheap as now. (It has been estimated that the Pittsburgh deposits are likely to last two hundred years or more, according to the rate of increase in production.)

But the most of the furnaces are situated outside of the city proper, and the annoyance of smoke and soot from the steel and iron works is less than is generally supposed. Many visitors express surprise over the small amount of smoke, as compared with what was expected; and it is not unusual to hear it said that Pittsburgh is not perceptibly smokier than many other places.

But the Pittsburgher makes no such claim. The Iron City is blacker and more smoky than most towns; although it is certainly not so bad as its reputation. And it is going to be very much better. For years those of her citizens interested in civic improvement have been fighting for a smoke ordinance; and now one has been carried through—a good one, which will stand: it has been framed upon corrective and improved lines. The people have learned through hard experience how to do some things effectively. Establishments that have for years taken advantage of Pittsburgh's sooty reputation, and so allowed their chimneys to belch incontinently, are already being restrained.

Compared with many large manufacturing cities, the physical conditions in Pittsburgh do not render it an especially undesirable place of residence; and a little journey through the East End divisions of Oakland, East Liberty or Swissvale would convince almost any person who views the miles of handsome residences and well-kept grounds. And the surroundings and suburbs extending for miles down the Ohio River are quite unusually beautiful. Moreover, contrary to a supposition which prevails in other places, Pittsburgh is not unhealthful. According to the statistics, Allegheny County will bear comparison in healthfulness with almost any of the larger centers of population.

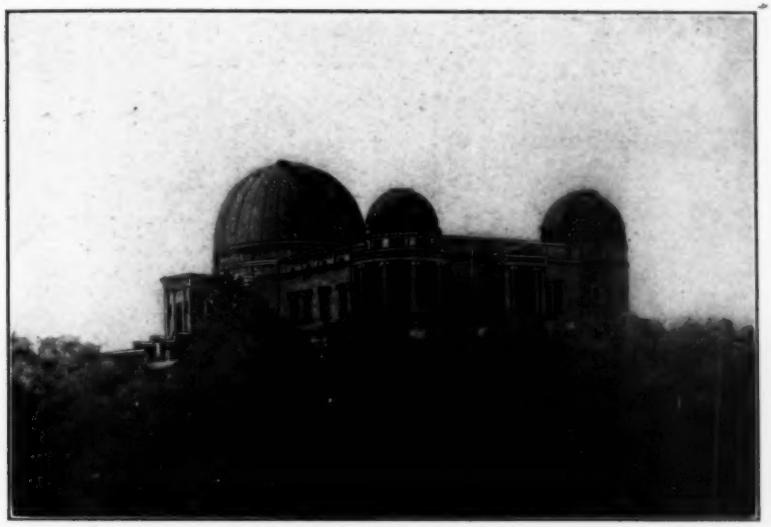
Architecturally, there is much that can be said for Pittsburgh, as compared with other cities of equal prominence; and a good deal has been written thereon. The Allegheny County Court House stands



THE CARNEGIE TECHNICAL SCHOOL.

as one of Richardson's masterpieces; and among the noteworthy structures are the new Carnegie Institute, the Technical Schools, quite a number of imposing and beautiful churches and the Nixon Theater—regarded as among the beautiful and artistic amusement places of the country. Choosing from among Pittsburgh's extraordinary number of modern skyscraper business edifices, it may doubtless be said with truth that the Frick Building is the finest of its kind anywhere.

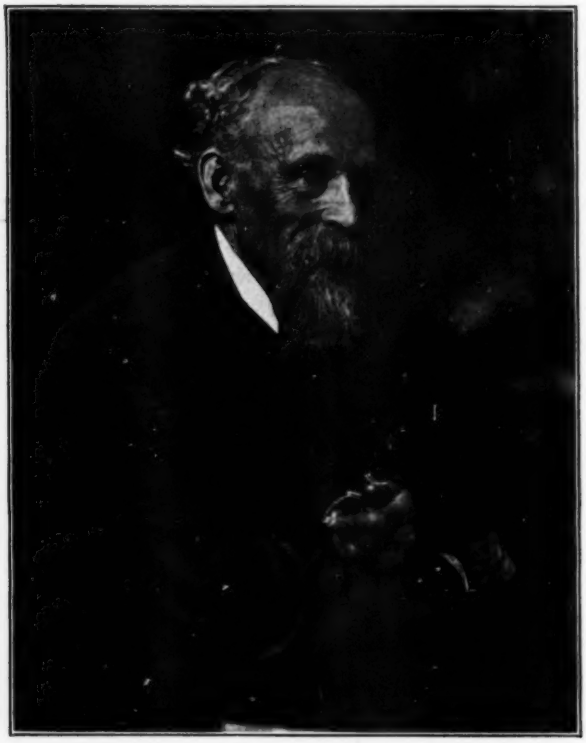
There is one feature that seems especially worthy of note. In no part of the city, practically speaking, are there *rows* of dwelling houses



ALLEGHENY OBSERVATORY.

built closely together—each house looking exactly like its neighbor. Possibly the city's sponsors remembered the experience of Glasgow, whence many examples and traditions were naturally derived. There the evils of overcrowding bore their ill fruit until some time in the sixties, when a great change was enforced. The inestimable benefit of wider spaces between residences should naturally have offered its lesson. At least, the builders of Pittsburgh knew—and profited from the knowledge.

The tenement districts must still be spoken of apologetically, for there are portions of Pittsburgh where the dwelling houses of the poor and working classes are decidedly bad. But the city is no worse than many others in this respect; and, moreover, Pittsburgh's fame as the great industrial paradise has caused an influx of laboring classes which no amount of intelligent study could have forestalled. As to general cleanliness there is much to be hoped for, and expected. Not all of the sections of the city are as well kept as they should be; but nobody doubts that conditions are to be improved in the near future.



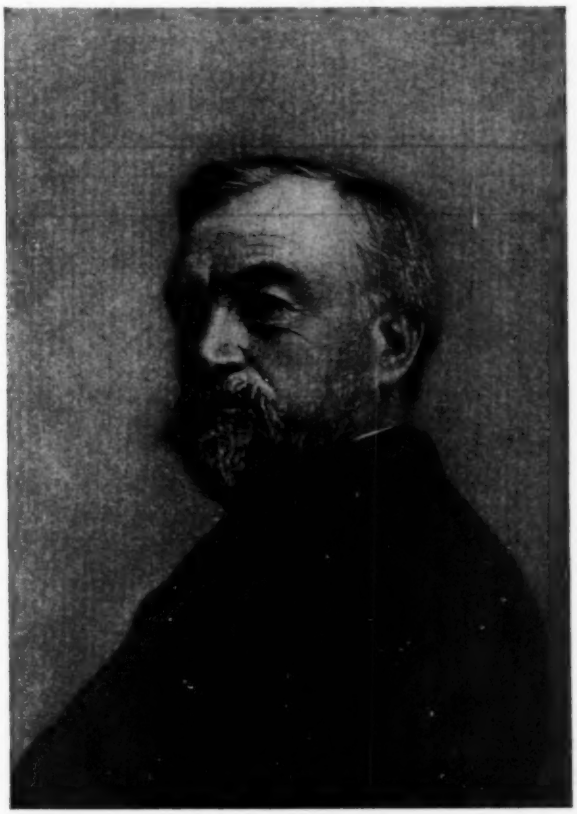
DOCTOR JOHN A. BRASHEAR.

The main business streets and the finer residential portions of the city are kept in as good condition as almost anywhere else.

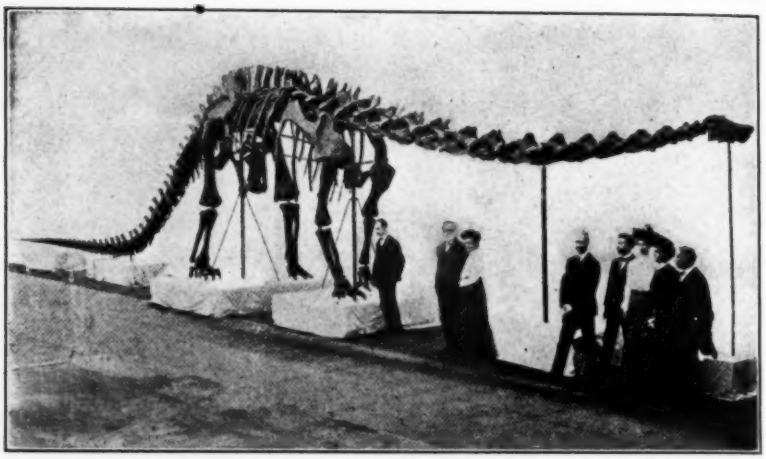
Thus far the reference has been to the physical and industrial aspects. There are other elements worthy of note; lines of broader development in which Pittsburgh has already attracted attention: wherein she promises to exert, some day, an influence over a wide area. These fields are represented by the Art Society, the Scientific Museum, the Pittsburgh Orchestra, the Public Library System, the Technical Schools, and the Astrophysical Observatory affiliated with the Western University of Pennsylvania. One distinction must be named. the observatory represents a field that has long since "arrived." Its work is known to science the world over.

The Pittsburgh Art Society was born in 1873; and out of that society of thirty-five years ago have been developed the Carnegie Art Galleries and the Pittsburgh Orchestra. The Museum, the Art Galleries and the Technical School are several parts of the Carnegie Institute, toward the upbuilding of which, together with the library, Andrew Carnegie has given many millions of dollars. The orchestra is a separate entity, now self-supporting.

In the cultivation of the fine arts, the Art Department of the Carnegie Institute has unquestionably given to Pittsburgh a great stimulus. The galleries contain a fine permanent collection of paintings and sculpture, the property of the institute, as well as numerous paintings which have been loaned by private owners for an indefinite period. This exhibit is open to the public daily during the greater part of the year, and no charge for admission is made. Each year the department holds a competitive exhibition of paintings, which is open to the artists of the world; and these exhibitions have become of international importance. Hundreds of paintings are sent by noted artists of Europe and America; the efforts of the directors tending toward the elimination of favoritism, and the fostering of a spirit of fairness. This broad policy of the Art Society is influencing the artistic spirit at home and abroad. The children of the public schools are encouraged to interest themselves in the art exhibits; and art talks are given by the director to classes of children from the schools. Incidentally, Pittsburgh has in the past contributed a few names to the world of art. In the list of



SAMUEL PIERPONT LANGLEY.



DIPLODOCUS CARNEGIEI HATCHER; Order of Dinosauria: in Carnegie Museum; 84 feet in length; found by the Carnegie Expedition under John Bell Hatcher, in Jurassic beds, Sheep Creek Basin, Wyoming, in 1900. The only complete specimen ever found.—A *replica* is in the British Museum.

eminent artists who have lived in the city are John W. Alexander, Charles S. Reinhart, A. G. Reinhart, George Hetzel, William, Alfred and Bryan Wall, Clarence Johns, David Blythe and others.

The new institute building, usually so called, is an Italian Renaissance structure covering four acres, and containing the Library, the Museum, the Fine Arts galleries, and the Hall of Music. The Technical Schools have another location. The museum has over 100,000 square feet of floor space on the first, second and third stories; and a special library which takes up one end of the great central court. In the basement are rooms devoted to the curator's work, and the preparation of specimens. The lecture hall seating between six and seven hundred people opens from the museum section; and here the Academy of Science and Art holds meetings, and provides lectures which are free to the public. At present there are in the museum over 1,300,000 objects on exhibition. The aim is to not only illustrate and interest, but to educate the masses in matters of fauna and flora, geology and mineralogy. Research and science are furthered by the systematic collections in its library.

In the field of music, the Pittsburgh Orchestra has achieved national distinction—going back to the earlier days when Frederic Archer was its first conductor. Mr. Archer also played the magnificent organ for many years. When he died Edwin H. Lemare became organist; while the directorship was taken up by Victor Herbert. Under Herbert the orchestra became famous as one of the leading musical institutions of the country; and under Emil Paur, the present conductor, whose reputation is international, it has reached a still higher level. The concerts are always well attended, although they are not free. A

series is given in Pittsburgh every year; and usually a tour is made of the larger cities. Twice a week during a large portion of the year free organ recitals are given in the music hall of the institute. Taken for all in all the Pittsburgh orchestra is doubtless exercising a rather broad influence in musical matters. Every year there is a season of grand opera, which is always popular. As a rule the churches have excellent choirs, and many have talented organists.

The library (reference here is to the Pittsburgh Library distinctively, since there is also a fine Carnegie Library across the river on the north side—formerly Allegheny) has found as wide and excellent a field of influence, perhaps, as has almost any institution of the kind anywhere. The plan was developed by Librarian Edwin H. Anderson, who was its head from 1895 to 1905, and embraces among many features the furnishing of collections of books to the public schools and to the vacation and summer schools; the establishment of numerous branches in large centers of population; the Home Libraries department for children; and a liberal encouragement of the use of library books by all classes of people. The encouragement has been particularly directed toward the laboring classes and poorer people. This work has reached an unusual degree of appreciation. The library has (1907) 300,000 volumes; and a few figures relating to the book circulation may be of interest. The present home circulation (that is, books taken out to carry into the homes of the people) is more than 800,000. The entire recorded use of books from the library in 1907

PALM ROOM, PHIPPS CONSERVATORY, SCHENLEY PARK.

SKYLINE OF PITTSBURGH.

was 1,463,207. Of the entire withdrawals from the library, the percentage of fiction to the whole was less than 58 per cent. It is stated by the librarian, Mr. Hopkins, that the withdrawals in 1908 will probably exceed two millions. The Boston Public Library had, last year, a total of 903,349 books. In 1907 the report of the Boston Library showed a home circulation of 1,461,403. The report states that of this number 70 per cent. "very nearly" of the entire withdrawals was fiction: including juvenile books, the percentage of fiction was much greater. These comparative figures are worth considering, since they indicate the importance to the community of the work of the Pittsburgh Library. It would perhaps hardly have been supposed that the relative proportion of *useful* books, namely, works of science, history, travel, philosophy, art, biography and religion, which are being read in a community composed so largely of workers in the industrial trades, exceeds the showing of the Boston Library by 12 per cent.

The Carnegie Technical Schools were established in October, 1905; and they have a present endowment of four million dollars. There are four schools: for engineers; artists and designers; tradesmen; and women; and their development has been according as space could be made ready. At present the accommodations are not adequate; but when the fine and commodious School of Applied Science is finished, next September, it is anticipated that the present departments will all be adequately housed. As time passes, buildings will be erected as necessities demand and funds permit. The statement is made that the buildings now provided equal not more than one seventh of the future's needs. The number of students at present, in all departments, is 1,750. They come from thirty states; and it is reasonably anticipated that the schools are going to draw from all quarters of the world. The growth is very rapid, in appreciation and interest.

The School of Engineering comprises electrical, mechanical, civil, metallurgical and chemical; while under architectural, a department is maintained by itself. The School of Design is virtually that of architectural design.

The trade courses embrace draughting, electrical wiring, plumbing, bricklaying, sheet metal and cornice work. (In one of the lofty rooms of this department a complete two-story house is in course of construction, wherein all of the technical features of electrical wiring and equipment, plumbing, drainage, etc., are carefully demonstrated.) The trade courses also involve foundry practise, forging, pattern making; machine-shop practise; house and sign painting.

The Women's School comprises technical courses for the daytime; and trade courses in the night schools. In the technical courses are mathematics, English history, social ethics, chemistry, drawing and designing. Also, departments of dressmaking and millinery are included. There is a special department intended for professional

housekeepers, matrons and hospital managers, with professional courses in these lines.

The night school for women comprises purely trade courses, aiming to make the services of women more valuable. These courses embrace bookkeeping, stenography, typewriting, cooking, dressmaking. Those

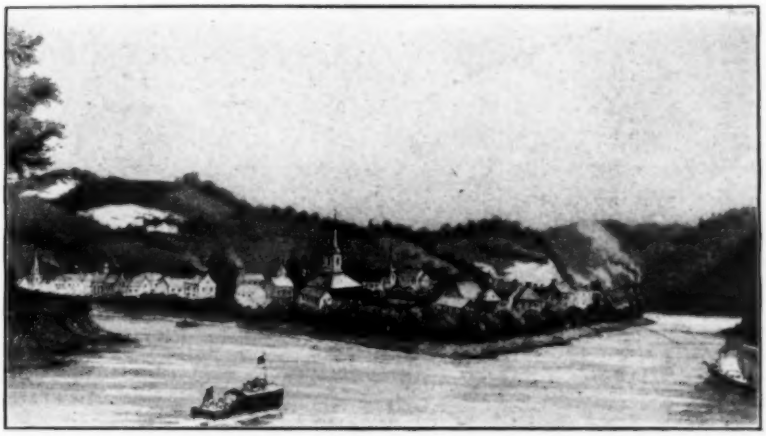
SIXTH AVENUE CHURCHES AND SKYSCRAPERS.

who take up stenography must study commercial law; and those who study cooking must take instruction in the chemistry of foods.

It is the aim of the institution as a whole to keep abreast of all matters of technical science. The faculty has been most carefully selected; and the determination is to get men practical experience—

men who know what to go after and how to obtain and present the most valuable kind of knowledge. There is one main purpose, differing from any that has hitherto been tried: the length of the course is indeterminate. The argument given is, the impossibility in a collection of students to have all equally trained or equally efficient within a given time. Each student must, in a sense, be the arbiter of his own destiny: he must get a certain work done before he obtains his certificate. If he fails to do this, he is given instead a statement to the effect that whereas he has been in the institution a certain number of years, he has merely covered a certain ground creditably. The certificate still awaits his future efforts and accomplishment.

Everything is done to bring the advantages and resources of the schools within reach of the plain people. In other words, it goes down



PITTSBURGH IN 1817.

to them, and after them. The type that it is designed to reach is the middle-class boy. There are some boys of wealthy parents in the schools; and doubtless there will continue to be a certain percentage always; but he is not the type. The theory is that the country boy or the son of poor parents is going to bear the future load in technical and industrial life. It is also recognized that it is from these strata that the best results are sure to come—that the young man who has had the hardest struggle, to whom life presents the greatest problems and the most toil and effort, is the coming man. He is far more certain to achieve success and a name. Great emphasis is laid on the personality of the student: he must have the proper attitude toward work; he must be active, bright, always industrious, and never slovenly in his work.

The intention of the school is to have its heads composed of men whom the students will seek from afar. The members of the faculty

shall be men sought by students from everywhere, for sake even of the one man.

The feeling of democracy is cultivated; and every discouragement possible is thrown in the way of dividing into high and low castes, upper and lower strata, cliques or classes.

The tuition fee is nominal. The directors wish it understood that while the school gives courses in engineering and the trades which are on an equal footing with other institutions, yet it is not the aim to turn out skilled or practised engineers or mechanics. What is claimed is that the institution can turn out those who are *capable of becoming* better engineers and mechanics than those who have lesser opportunities, or training not so good. That which only can develop the mature engineer or mechanic is future practical experience.

Another aim of the institution, already very effective, is the finding of employment to aid indigent students in working their way through. It is not claimed that employment is provided for every student who now applies for it; but that much is being done, and much more will be done in the future. During 1907 over 600 men students applied for employment through the secretary of the schools. Approximately 350 positions were offered, and nearly 300 positions were filled by students, making up an aggregate earning capacity of upwards of $25,000.

The Western University of Pennsylvania is, with one exception (the University of Nashville), the oldest institution of learning west of the Appalachian Mountain ranges. It has an enrollment to-day of somewhat more than 1,100 students; and besides the Department of Astrophysics (of which, more hereafter) there are five main departments, namely: Engineering, Law, Medicine, Pharmacy and Dentistry. The buildings are now scattered; but the plans for the future involve the concentration of all departments on a new site. The location is most admirable, consisting of 43 acres adjacent to the Carnegie Institute, and the Technical Schools. A race for development seems not unlikely to grow up between this institution and the Technical Schools, both of which seem destined to become strong educational factors.

It was in the year 1867 that Samuel Pierpont Langley was appointed to the chair of astronomy and physics in the Western University of Pennsylvania; and beginning almost from that time the Allegheny Observatory has held a place among the working observatories of the world. The equipment contained only a thirteen-inch equatorial telescope; and necessity, then as always the greatest spur to progress, stimulated Langley's fertile brain for a means of providing his observatory with better apparatus. For some years he labored with the problem of electrical time signals for railroads, in which he was finally successful, introducing the time signals on the Pennsylvania system, and other railroads in the district. Since then observatory

time has been supplied from various observatories to nearly all railroads. Returning after a number of solar eclipse expeditions, Langley began, about 1870 to study solar phenomena, in which he became one of the highest authorities, proving, among other things, that the absorption by the earth's atmosphere of solar heat is variable, and that sunspots have no appreciable effect upon the temperature of the earth. In 1885 he gave the results of some of his investigations in solar phenomena before the Royal Society in London. During his charge of the Allegheny Observatory he contributed upwards of a hundred papers to scientific journals. In his studies of solar physics, recognizing that the instruments were inadequate to record much of the sun's radiant

ENTRANCE TO HIGHLAND PARK.

energy, he began a long series of experiments which resulted in the invention of that marvelously delicate instrument, the bolometer. With this perfected, he renewed his investigations of the sun, moon and stars, which brought to light facts as important as any in the whole realm of astronomical physics.

Beginning with Langley's charge of the observatory there had grown up a valuable and intimate association with John A. Brashear, which continued after Langley's transference to the Smithsonian Institution, and until his death. The bolometer could not have achieved its wonderful success without Brashear's mechanical and scientific assistance. Experiments had shown that transparent crystals of rock-salt have the faculty of transmitting the low heat rays of the sun (that is,

the invisible rays below the red); and Brashear undertook the solution of the problem of producing accurate surfaces upon lenses and prisms made of this substance. Its deliquescent character was a factor very difficult to contend with, but a method was discovered by which surfaces were produced within a half light wave, answering to the most critical demands of Langley's bolometric research. During a visit to the Chicago World's fair, in 1893, some unusually fine rock-salt crystals from mines in Poland were found in the Russian exhibit, which were secured for the Smithsonian Institution, from which some of the largest and finest lenses and prisms were made. Langley's joy in

SMITHFIELD STREET

Brashear's success was boundless—and naturally so. The proportion of invisible radiated heat, underneath the red part of the sun, is many times greater than the visible rays. It is through the curious quality of rock-salt lenses and prisms that it became possible to concentrate the dark, lower heat rays, and to achieve the splendid results with the bolometer.

Professor Langley's life work and the honors that have been heaped upon him are so well known that to enumerate them would be supererogatory. The secretaryship of the Smithsonian Institution is the highest gift of science in America, and this honor he held for nearly twenty years, until his death in 1906. He was given the Rumford Medal of the London Royal Society, and elected to a membership in that body; was president of the American Association for the Advance-

ment of Science, besides having other honorary memberships and degrees in large number.

John A. Brashear began to make telescopes as a business in 1880; although his first telescope, a refractor of five-inch aperture, was made in 1872–5. When it is remembered that Brashear had reached middle life before he relinquished his employment as master mechanic in the rolling mills to begin experimenting in the field of optics and astronomy, the amount of valuable scientific work he has accomplished in the thirty-odd subsequent years is fairly amazing. He made many pieces of apparatus for Professor Langley's studies; besides a long list, impossible to enumerate here, of telescopes, reflecting lenses, mirrors and spectroscopes for astronomers' use in all parts of the world. He has sent instruments to England, Ireland, France, Germany, Egypt, South Africa, Australia, Syria, Italy, Argentina, Japan and numerous other countries, besides an endless series of apparatus for use in the United States and Canada. One reflecting telescope which he himself used in a three years' study of the floor of the lunar crater Plato, was in constant use afterwards by Professor Langley. Brashear developed a highly valuable method of silvering mirrors, which was freely given to the scientific world; published a paper on "A New Method of Correcting Errors of Curvature in Optical Surfaces," which has proved invaluable; constructed apparatus for measuring the velocity of light, and also to measure the differential velocities between long and short waves; many refractometers, and optical trains—among which were two for Lord Rayleigh with error not exceeding 1/1,500,000 of an inch. He constructed the first spectro-photoheliograph for Professor Hale, a work that was epoch-making in the realm of solar photography. One of his spectroscopes made for Professor James E. Keeler, of Allegheny Observatory, was the instrument used by Keeler in the discovery of the physical character of the rings of Saturn, proving the correctness of the Clark Maxwell mathematical theory. One of his finest instruments is the Mills spectrograph for the Lick Observatory, used by Professor Campbell in his many discoveries of the motions of stars in the line of sight. With the cameras he has built for astronomical photography a hundred new planetoids have been discovered. He has made, perhaps, the largest perfect plane in existence, 33-inch diameter. He has just completed the 37½-inch mirror of the great Cassegrain telescope for the University of Michigan; and is now constructing a 30-inch refractor for the Allegheny Observatory and a 24-inch for Swarthmore; and has orders for enough large and important instruments to tax the capacity of his workshop for more than two years.

Data about the hundreds of pieces of apparatus that he has made would fill a book. And besides, he has raised by his own personal efforts nearly three hundred thousand dollars for the construction of

the new astrophysical observatory of the Western University of Pennsylvania—the equal of any in the world. "I can not say," he says, "that the bank balance bears a fair relation to the work we have done," but he adds that in view of the marvelous discoveries made, and the appreciative and kind treatment he has had from the world, he feels like saying, "I am content. . . . I have that which can not be bought by dollars and cents." Dr. Brashear always emphasizes that his associate and son-in-law, James B. McDowell, is master of the development of the delicate work in optical service; and that he could never have made his success without McDowell's cooperation. Dr. Charles S. Hastings, of Yale University has also been associated with Dr. Brashear in the development of the mathematical problems of modern optics: the day of empiricism in optical science having become a thing of the past. Dr. Brashear has twice been a director of the Allegheny Observatory; and is now chairman of the Observatory Committee; he served two and a half years as acting chancellor of the Western University of Pennsylvania. He has degrees of LL.D. from Wooster University of Ohio and Washington-Jefferson Unversity, as well as degree of Sc.D. from the Western University.

Pittsburgh's "arrogance and greed" have been so advertised that it should be permissible to mention that the city contains more than one hundred and fifty active benevolent and charitable institutions; more than twenty large, finely equipped hospitals; and over four hundred churches of all denominations. It is scarcely more of an iron city than a city of churches and church-going people. There are benevolent societies, non-sectarian and sectarian; homes for the destitute, aged, infirm, white and colored, for men, women, girls and children; public baths for the poor; children's playgrounds for poor children.

One of the most notable institutions (undoubtedly the most remarkable single-handed permanent beneficence in the world) is the Carnegie Relief Fund, endowed five years ago by Andrew Carnegie, with a gift of four million dollars in Steel Company bonds. This fund applies to more than 65,000 men employed in the iron and steel trades, who, with their families and dependents, would comprise an aggregate population of over 300,000 persons. The bonds bear good interest, and the income provides for accidents, deaths and pensions. There has been a total disbursement already of $1,129,117.29. In 1907 the amount paid out was $216,764.03.

A well-known writer has said that Pittsburgh men are strong, upright and good intentioned, but "too busy" in the upbuilding of industries and fortunes to pay attention to the civic welfare. Perhaps the utterance was timely; for since then the long-delayed civic awakening has come to pass. The betterment, always hoped for—regarded by the many as impossibly Utopian, but always fought for by a tenacious and stubborn few—is an accomplished and positive fact. Two years

ago the fighting citizens seized a political opportunity; and Pittsburgh has in Mayor George W. Guthrie an executive of whom it is justly proud. Not even by his bitter political opponents is he charged with any wish or motive that is foreign to the highest interest of the city. From a machine-ridden, ring-encircled municipality, the revolutionizing and purging have been so thorough that political corruption is now virtually non-existent. It is no longer "a city ashamed"; it is joyful and proud.

Anxious critics have inquired whether Pittsburgh's sudden and untoward opulence is a menace—a menace to itself, and to humanity. The city has been adding a chapter or two to the history of sociology. It has turned out (*promoted* is perhaps more accurate) a new and curious variety of plutocrat; and still worse, has produced a new leisure class. The latter was born out of the loins of toiling industry; has sprung upon an amazed world within a decade; and the funny twins have made an unwelcome commotion. It is seriously asked whether these do not furnish a gauge by which the future manhood of Pittsburgh is to be determined: whether they are not the prolific seeds of complete degeneracy.

The answer is to be found in the fact that Pittsburgh was raised up by the brain and brawn, the self-respecting moral qualities of its Scotch-Irish founders. They were, and are yet, a forceful race—fighters and workers, natural leaders, men with a high sense of duty, who do their own thinking. Do the critics see no signs of the vital undercurrent which is to be the determining factor of the future? Do they not see in Pittsburgh's intellectual activity a guaranty of the more wonderful reputation which is to be achieved hereafter, when the present spendthrift perversions and pranks have been long forgotten? Just as it has been in the past, so now the vicious idler is made to feel uncomfortable. His father toiled for his winnings, is toiling yet, if he lives, and the son who lives only to spend money and invent new and outrageous forms of diversion is a virtual outcast. And yet he is an almost inevitable outgrowth of the marvelous period. He is not confined to Pittsburgh; but has merely been somewhat disproportionately advertised. And doubtless, too, his number is small as compared with what it might have been had the principles of his progenitors been less firmly anchored. He will not increase. Pittsburgh has even a confident hope that he and his tribe may become extinct.

THE EDUCATION OF THE COLORED RACE IS THE DUTY OF THE NATION

By Professor HARRIS HANCOCK
UNIVERSITY OF CINCINNATI

FORTY years ago the civil war was ended, the negro freed. Individually there will always be persons who entertain feelings of animosity against their fellow man of another section; for sectionalism will ever exist. But as a nation such feelings must be buried, if there are any which influence the political government of the people. For every section is a part of the nation and the nation is under equal obligations to every section. Each state is an integral part of the nation, and no state may be regarded by the union as a province.

It is a historical fact that slavery was forced upon this country by England against the protests of the states, both north and south. For example, in 1769 the House of Burgesses of Virginia by a vote *abolished slavery,* but was prohibited from so doing by George III., King of England, "in the interests of commerce." Further, in 1778 Virginia, and in 1798 Georgia, passed acts prohibiting the importation of slaves, Virginia fixing as a penalty the heavy fine of one thousand pounds; it is also true that Virginia, Tennessee and Kentucky were banded together in the support of a practical system of emancipating the slaves by degrees, a movement which was eventually stopped by the abolitionists, a party that came into existence after the Missouri compromise, in 1820–21. This party demanded the immediate and uncompensated freedom of all slaves, notwithstanding the fact that England had just liberated four hundred thousand slaves at the cost of twenty million pounds. No other such attack upon private property can be found in the history of civilized nations. We emphasize the fact that some of the southern states led the world in an earnest appeal to prevent slavery, although with a peculiar irony the world to-day holds the south responsible absolutely for the existence of this institution. And further to show that the nation as a whole was responsible for the existence of the colored race in America, it must be recognized that although the south was at that time somewhat of a maritime people, *no slave was ever brought to this country by a southern vessel,* and that "New England ship-owners practically monopolized the traffic of slavery for a number of years."[1] It is also found that Massachusetts was the first colonial state (1641) that legalized slave

[1] See "The True Civil War," pp. 28, 29, 30; and in this connection see also "Origin of the Late War," by George Lunt, an eminent lawyer of Massachusetts.

traffic in America. Slavery existed at the north, as long as it was found profitable, and throughout the nation slaves were regarded as "property." This was a heritage handed down to us from England, in which country a law was enacted in 1713, the venerable Holt presiding, that held slaves to be "merchandise."

Thus the presence of the negro slaves in America was legally established by the courts of England and was for the most part effected through vessels of New England. Being more profitable in the south, they were soon gathered together there in great numbers.

It is not the purpose of the writer to go into the causes of the civil war, to consider which side was right, which wrong, or whether either side was either right or wrong. He believes that historians of the future will agree with Mr. Lunt when he says: "Self-seeking and ambitious demagogues, the pest of republics, disturbed the equilibrium, and were able at length to plunge this country into the worst of all calamities—civil war. The question of morals had as little as possible to do with the result."

The advocates of emancipation always declared that *the fate of the colored man was a responsibility of the whole nation.* This doctrine was accepted as a fact by the United States government and the colored man was eventually freed. But having accepted the responsibility of this race, *it is and always has been the duty of the whole nation to care for the improvement and education of the colored man.* His up-building, however, has been left entirely to the charge of the south, which consequently has had to assume the task of "educating two races out of the poverty of one."

It may be noted here that the national census shows that from 1860 to 1870 the assessed value of southern property diminished by practically one half, while the increase in northern property was approximately multiplied by two. And upon this basis the northern states by means of the protective tariff and other legislations have increased in wealth far more rapidly than those parts of the country which are primarily agricultural.

The disparity that is thereby produced in the funds for the education of the children in the different sections at the present time is seen from the following statement: The average amount spent in the United States at large is—per capita of the pupils in average attendance—$21.38; in the western states the average expenditure is $31.59, while for such states as Alabama and the Carolinas this expenditure is approximately $4.50. These figures are given by Mr. Murphy in an address delivered before the General Session of the National Education Association, Boston, July 10, 1903. In this address Mr. Murphy says:[2] "A democracy which imposes an equal distribution of

[2] *Cf.* also Murphy, "The Present South," p. 42.

political obligations must find some way to afford a more equal distribution of educational opportunities."

The urgent needs of better educational facilities in the south are at once apparent from the following statement:

The illiteracy of the native white population (meaning those who can neither read nor write) ranges from 8.6 per cent. in Florida, 8 per cent. in Mississippi and 6.1 per cent. in Texas to 17.3 per cent. in Louisiana and 19.5 in North Carolina; as contrasted with 0.8 per cent. in Nebraska, 1.3 per cent. in Kansas, 2.1 per cent. in Illinois, 1.2 per cent. in New York and 0.8 per cent. in Massachusetts. In all the states taken outside the southern states and forming a group, the average rate of illiteracy among the native white population is only 2.8 per cent. as against 12.2 per cent. of native white illiterates in the south.

According to the figures of Dr. Charles W. Dabney,[3] there are 3,500,000 people in the south ten years of age and over, who can not read and write, of these about 50 per cent. of the colored population and 12.5 per cent. of the white.

In 1900, the states south of the Potomac and east of the Mississippi contained in round numbers 16,400,000 people, of whom there were 10,400,000 white and 6,000,000 black.

In these states there are 3,981,000 white children from five to twenty years old and 2,420,000 black children of the same age, making a total of 6,401,000 children to be educated.

These are distributed among the states as follows (see the above-mentioned report):

	White.	Colored.	Total.
Virginia	436,000	269,000	705,000
West Virginia	342,000	12,000	354,000
North Carolina	491,000	263,000	754,000
South Carolina	218,000	342,000	560,000
Georgia	458,000	428,000	886,000
Florida	110,000	87,000	197,000
Alabama	390,000	340,000	730,000
Mississippi	253,000	380,000	633,000
Tennessee	590,000	191,000	781,000
Kentucky	693,000	105,000	798,000
Total	3,981,000	2,420,000	6,398,000
Arkansas	381,000	149,000	530,000
Louisiana	277,000	262,000	539,000
Texas	956,000	260,000	1,216,000

Only 60 per cent. of these children were enrolled in the schools in 1900 and the average daily attendance was only 70 per cent. of those enrolled; so that only *42 per cent. of the southern children are*

[3] See Report of the Proceedings of the Sixth Conference for Education in the South.

actually at school. One half of the negroes get no schooling whatever and one white child in five is left wholly illiterate.

In North Carolina the average citizen gets only ..... 2.6 years' schooling.
In South Carolina the average citizen gets only ..... 2.5 years' schooling.
In Alabama the average citizen gets only ..... 2.4 years' schooling.

In the whole south the average citizen gets only three years' schooling. *And what sort of schooling is it?* The answer may be inferred from what is found elsewhere in this discussion.

In North Carolina the average value of school property is $180
In South Carolina the average value of school property is 175
In Georgia the average value of school property is 523
In Alabama the average value of school property is 512
The average monthly salary of a teacher in North Carolina is $23.36
The average monthly salary of a teacher in South Carolina is 23.20
The average monthly salary of a teacher in Georgia is 27.00
The average monthly salary of a teacher in Alabama is 27.50
The schools of North Carolina are open on an average of 70.8 days per year.
The schools of South Carolina are open on an average of 88.4 days per year.
The schools of Georgia are open on an average of ..... 112.0 days per year.
The average expenditure per pupil in average attendance is $4.54 per annum in North Carolina.
The average expenditure per pupil in average attendance is $4.44 per annum in South Carolina.
The average expenditure per pupil in average attendance is $6.64 per annum in Georgia.
The average expenditure per pupil in average attendance is $4.50 per annum in Alabama.

In other words, in these states in schoolhouses costing an average of $276 each, under teachers receiving an average salary of $25 per month, we have been giving the children in actual attendance five cents' worth of education a day for 87 days only in the year.[4]

These figures, compared with those indicating like expenditures in the other states of the union, show that the expenditures in those states are from four to six times as great as in the south.

Mr. Geo. S. Dickinson of New Haven, Conn., one of the best informed students of southern conditions,[5] says:

There is no end of bounty bestowed on institutions for the common people in the northern cities. Why, as an American, should I be more interested in the children of Boston or of New Haven than in those of the Carolinas and Georgia? Who are the children of Boston? Sixty-seven per cent. of them are of parentage from beyond the seas. Eighty per cent. of the children of New York are of such parentage, and the story is the same for the other great cities —Cleveland, Chicago, San Francisco. More than three quarters of their people are of foreign antecedents: Irish, Germans, French, Italians, Hungarians, Poles, Armenians, Chinese, Russians, etc.

[4] Chas. W. Dabney, *loc. cit.*

[5] *Cf.* also statistics given by him in Chap. XVIII. of Vol. I. of the Report of the U. S. Commissioner of Education for 1902 and also the *Southern Workman*, January, 1903.

Not that I would disparage the beneficent ministries of education for any of these. It is an occasion of joy. I only speak of what we are doing for them to emphasize what we ought to do for those of our own blood. It was the apostle to the gentiles engaged with all his might in efforts for the people of other races, who wrote: "If any provideth not for his own, and especially his own household, he hath denied the faith and is worse than infidel." And so, to-day, our interest in other people should deepen our sense of responsibility for those who are nearest of kin.

Who are these 10,000,000 whites of the south? They are the children of the colonial pioneers, of the soldiers who made the continental army, of the fathers who established the republic. They are many of them descendants from a New England ancestor as well as from settlers of Virginia and the Carolinas. A cursory study of the subject leads me to believe that in some counties of Georgia a larger proportion of the people can trace back through some line to a New England sire than in the city of Boston. The cracker is of the same blood as the merchant prince. This is to be seen in their very names. The people of the north and south are one, in feature and in native force, cherishing common religious beliefs and conserving the immemorial traditions of freedom and independence.

In Alaska the expenditure upon the children of the nation, although sixty per cent. of them are Eskimo, is annually $17.78 per capita of enrolment. Similar provisions are being made for the children of the Filipino, while $4.41 is annually spent[6] upon the student of Alabama, and this too when the people of Alabama are taxed to pay for the education of the Eskimo and Filipino.

We make no criticism regarding the money spent upon the children of our territories. Attention, however, should be called to the fact that our government has already spent more money on the Philippine Islands than would be required to educate our entire negro population for the next fifty years, as is shown by the figures given below. And the United States now considers itself under moral obligation to the civilized world to educate the Filipinos and make them responsible citizens.

The most elementary mathematics applied to the principles of sociology will show that millions of dollars will be required to make of this people a nation comparable to others of the civilized world. Suppose that this result may be achieved, what guaranty is there that the Filipinoes will be our friends and allies in time of trouble, say in the case of a foreign war; or what recompense do we gain from the civilized world for "moral obligations" rendered? Charity begins at home and a nation must consider carefully its *own* ultimate safety and welfare.

We do not claim that the education of the negro is a charity due him by the nation, nor do we wish to consider it a part of friendship of the people of the north to the white people of the south, nor do we hold it a part of philanthropy or a moral obligation to the outside

[6] These figures, of course, vary slightly from year to year.

civilized world. We assert that it is a fundamental duty of the United States government to its own citizenship in the promotion of morality and in the establishment of every department of industry, invention and manufacture which ultimately tends to the improvement, progress and prosperity of the nation as a whole and stands as a bulwark of strength in the time of trouble.

Granting the correctness of statistics already given, every true citizen of the nation will admit that the present conditions existing for the education of southern children must be improved. The writer has ventured to outline a method[1] by which this may be accomplished. It is evident that if the United States government assumes the responsibility of the education of the colored children of the south, the white people, relieved of this burden, will be the better able to meet the educational requirements of their own children.

There are 600 places in the southern states, not counting Virginia, Maryland and Kentucky, which contain 1,000 people or over. In these dwell about 3,000,000 people, white and colored. The other 14,000,000 are country people. This number is over 17,000,000 if the above-named states are added. About 10,000,000 of these are native white Americans with 3,500,000 children to be educated; and there are seven millions of colored people with 2,500,000 children to be educated.

The area of this country is seen in the following table:

	Square Miles.
Virginia	42,450
North Carolina	52,250
South Carolina	30,570
Georgia	59,470
Florida	58,680
Alabama	52,250
Mississippi	46,810
Louisiana	48,720
Arkansas	53,850
Tennessee	42,050
Total	487,100
Kentucky	40,400
Texas	265,780
West Virginia	24,780
Maryland	12,210

Owing to the small proportion of colored people with respect to the total population in Kentucky and West Virginia and the small proportion of them in comparison with the great area of Texas, these states are omitted from the present calculations. Other appropria-

[1] This method must be regarded as merely provisional. It is intended for the most part to give an idea of the expenses necessary for an adequate education of the colored race.

tions may be made for these states as are found necessary after the proposed system of education has been put into operation in the states where the great masses of negro population are found. Counting Maryland, there are practically 500,000 square miles of this country that are densely populated with colored people.

One schoolhouse for each sixteen square miles would make the average distance about a mile that each child would have to walk. In no case would this distance be as great as three miles. This is seen by forming a square, each side being four miles, and by placing the school house in the center of the square. These buildings, however, may be placed nearer together or farther apart according to the density of the population.

A schoolhouse with grounds may be secured for $500, which property may be kept in repairs with funds mentioned later. Teachers in most localities may be readily secured at $40 per month and six days per week, so that the expenditure below may be regarded as quite sufficient.

A teacher at $50 per month for ten months—$500. His time may be divided between two schoolhouses, he teaching five months at the one and five months at the other, or he might teach alternate days at either schoolhouse, in which case he should live about halfway between the two. In the latter case, which seems preferable, the pupil has less time to forget what he has already acquired and besides he may be of considerable service to his parents.[8]

Beginning at eight years old, the child should be required to attend school six years. If it attends school a longer time, payments for the same should be made. This money may be used to help in part to keep the schoolhouse in repairs.

About thirty thousand schoolhouses are necessary for the above area of territory. These houses would require an initial expenditure of $15,000,000. All of this sum need not be used at one time, as it will take several years for the consummation of the system and in the building of the houses. The yearly expenditure for the thirty thousand teachers, fuel, etc., at say $250 per house is $7,500,000. This is about the cost of one battleship.

In the six years of primary study these children may learn good behavior, discipline, reading, writing, arithmetic, geography, spelling, elementary grammar, elementary history, something about farming. The average pupil in the primary school will for ages to come be more adapted to working the land than for any other occupation. The ex-

[8] A successful system is in operation in the University of Cincinnati among some of the engineering students, who spend alternate weeks at the university and at their employers' factories. These students are thus able in six years to earn their way through the engineering course.

ceptional scholar (and there will be about one in thirty) should be given an opportunity at the higher schools of becoming teachers, preachers, doctors, shoemakers, wheelwrights, etc. They should also be fitted to fill the better positions in manufacturing and mining establishments. Before entering these higher institutions the pupil should be made to pass satisfactory matriculation examinations and it should be shown that he is of good character.

Such schools as Hampton and Tuskegee may be established in each of the southern states. In them industrial education should be especially emphasized, and the training of preachers, doctors and teachers (who wish to teach in the lower schools) should be provided for. These schools will be for the colored people what the universities are for the white people. They may be supported through taxation of the negro property and through the munificence of philanthropists interested in the colored race. About one fifteenth of the school money expended now is derived from taxation of negro property. Whether there is a necessity of having colored lawyers for the colored race is a question. There are already institutions in which an exceptionally clever negro may get a legal education. Any legal question may be settled by white lawyers, who for a long time to come will be more skilful in law and consequently the better able to represent their clients in the courts than colored lawyers. Further, I believe the negroes prefer to have their disputes settled by white people. But the teaching of the colored children and in most cases the care of the sick will be left to the colored people.

Whatever education a colored man possesses has been given to him by the people of the south; the present system for his education is due to the people among whom he lives, and this guiding influence must of necessity always be felt.

As shown below, the south is now spending annually at least $4,000,000 towards the education of the colored race. This money has been spent through the direction of the superintendent of public instruction in each state, and its disbursement has been supervised by the superintendents of common schools in the various counties and cities. These men have almost invariably exercised their duties with zeal and honesty. It seems desirable that these officers have charge of the funds for the education of both white and colored children as hitherto has been the case. Their salaries may be somewhat increased so that additional help in the way of secretaries and stenographers may be procured. Thus the expenses for the management of the fund for the education of colored children will be a minimum. The state superintendent should make annual reports of all moneys expended to some head man at Washington.

The office of the Commissioner of Education at Washington has

become of such importance that it is an urgent necessity that the head of this office be given a higher rank and be afforded better means of carrying on the great work for which he is responsible. Practically all the great nations of the world have for the discharge of such duties *Departments of Education,* presided over by officers that in this country would correspond to the *Secretary of Education.* At no distant day, the necessity of such an officer must be realized by our government. This officer would have the general management of all such funds as those proposed for the education of the colored race.

It does *not* seem either wise or politic that an ample appropriation once made should ever be increased. As the colored race increases, its capability of earning money should likewise increase, and consequently the taxes on its property should enhance yearly. The corresponding fund available for schools from these taxes should offset the growth of the race. It would be thus effected that the negro race is not entirely dependent upon the federal government for its education, but only in part, this part being relatively less the greater the growth of the population and the corresponding capability of earning money. Thus by the help of the federal government, the negro is given a good chance of making for himself a place in the nation and at the same time he is made dependent upon himself. In the ultimate growth of the nation no people can be expected to assume a responsibility of the education of another people. At the same time the stronger should for a period, say fifty years, lend a helping hand towards the upbuilding of the weaker.

Just as the religion of the white man has been disseminated among the colored people through negro preachers, so must all principles of morality, culture, ethics, etc., be derived from the white race and transmitted to the lower race through the agents of that race. The negro race must be developed along its own line by its own agents as a distinct race and as a separate people. Just as they have their own preachers, they must have their own doctors, their own teachers, etc. These leaders of the people must of necessity gain most of their information from the white man. As all learning is handed down to those in the lower strata of society by those who have reached the higher levels of efficiency, so must the negro ever continue to learn from the white man. That it is the duty as well as the policy of the white man to lend a helping hand no one will deny.

With remarkable foresight, the framers of most of the recent constitutions of the southern states have seen that it was equally a part of justice and to the interest of both races that a representation in the government of political affairs be based not only upon a property qualification, but also upon an educational qualification; and so through legislation they have effected that the upper section of the colored race

may enjoy the suffrage while the lower (the poor and illiterate) section of the white race is excluded therefrom. Thereby equal political rights are given to all. The southern states have thus through their own councils put into practise the very ideas that an unbiased writer, the great English political scientist and statesman, the Hon. James Bryce, advocated in his Romanes lecture, delivered at Oxford, June 7, 1902. By putting himself in this upper section, and not before then, can a colored man enjoy all the privileges of an American citizen. It remains that educational facilities be given him to accomplish this end. We claim that it is a primary duty of the federal government to aid the natives of its own states in becoming good citizens and that the "moral obligations" of this country must be first exercised within its own domains.

It has been shown above that the great masses of colored people live in rural districts. The Twelfth Census of the United States, Vol. V., pp. xciii, 4, 127, shows that in 1900 there were 732,362 farms operated by negroes in the south; that 150,000 southern negroes[9] owned their farms and that 28,000 more were part-owners. This shows a marked progress on the part of the negro farmer since the war.

It is clear that a good farmer increases the value of his own farm, and a good farm increases the value of the adjoining farms. Hence country property advances directly as the advance in intelligence of the agricultural laborer, and the advance in the intelligence of this laborer is made directly through the education of his children. Thus education makes labor more effective and thereby enhances the value of all farming lands. Viewed from its moral aspect, statistics have already been collected sufficient to show that the *literate negroes are the least criminal.*[10] It is practically axiomatic that among people closely identified the betterment of one race must also uplift the other, while the deterioration of the one must retard the progress of the other; and that either condition has a direct effect upon the nation at large. The danger of any commonwealth lies not in the education of any one class, but rather in the degeneracy of that class through lack of education; and the peril of the south is not in the rise and progress of the negro, but in his total downfall.[11]

[9] Booker T. Washington (*Tradesman*, Chattanooga, January 1, 1904, p. 99) claims almost double this number.

[10] *Cf.*, for example, Clarence A. Poe, of Raleigh, N. C., in *The Atlantic Monthly*, February, 1904.

[11] It is easy to show the fallacy of an apprehension entertained by some people that *the entire population of this country will eventually be "negroid."* For suppose, as an extreme case, that five per cent. of the colored population were mulattoes (one half black, one half white); *i. e.*, 19 blacks to one mulatto. (The true percentage is much smaller than the one assumed, which makes the hypothesis much in favor of the negroid proposition.) These mulattoes having

We may note the advantage gained by the white people of the south if they are relieved of the education of the colored people:

In the Report of the United States Commissioner of Education, 1899–1900, Vol. II., p. 2501, we find that during the thirty years up to that time, from 1870, the south expended $109,000,000 on the education of the colored people, or say $3,600,000 annually. This money should be added to the educational fund for the white children, and these funds must be gradually increased until they are doubled before these children will have anything like adequate educational advantages.

The average salary of a teacher is not $30 per month, while the average salary of a brickmason is at least double this amount. Further, the facilities that these teachers have had of obtaining knowledge and of equipping themselves for teachers have been very meager, so that many of them are very poorly educated. Hence there is a dearth of knowledge as well as of money in the schools, colleges and even universities. This unfortunate condition must be admitted, when we note that out of a total of $157,000,000 of productive funds held by American colleges, the south has but $15,000,000; the valuation of grounds and buildings of southern colleges is $8,500,000 in a total $146,000,000. The total annual income available for higher education in Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisi-

no social circle of their own cohabit as readily with the pure black as with another mulatto. Hence, *left to themselves*, among every 400 children of the second generation there would probably be:

361 (blacks),
38 (three fourths black, one fourth white),
1 (one half black, one half white);

while among 8,000 children of the third generation there probably will be:

6,859 (blacks),
1,083 (seven eighths black, one eighth white),
57 (three fourths black, one fourth white),
1 (one half black, one half white).

In other words, among 400 children of the second generation, there would probably be one child that has as much white blood in it as there was in its grandmother, and among 8,000 of the third generation there would probably be one as near white as its great-grandmother. *Thus negro returns to negro.*

In a similar manner it is seen that the number of children (three fourths white, and one fourth black) that are born in the second generation from mulatto women (one half black, one half white) is very small; while the number of those that are (seven eighths white, one eighth black) in the third generation born from women (three fourths white, one fourth black) is also small, etc. The ultimate white child is correspondingly rare.

Thus even if illicit sexual intercourse between the races existed to the extent supposed in the above hypothesis, it is evident that under the present conditions negro blood *can not* permeate the white. Mr. Bruce ("Plantation Negro," p. 243) claims that this intercourse practically does not exist, except in the cities, and that it is on the decline in the cities. Certain it is that miscegenation in the south is meeting with little toleration.

ana, Tennessee and Kentucky is $19,000 less than the yearly income of Harvard University.[12]

A southern state university considers itself fortunate if it receives an annual appropriation of from $50,000 to $75,000; and whereas in the larger universities, like Harvard, the professors teach from five to ten hours per week, it is necessary that they teach from twenty to thirty hours per week in the southern universities. This practically prevents the southern teachers from becoming great scholars in their respective fields, as they are able to do practically nothing in research work, when all of their nervous energy is expended in the class-room. They can, therefore, contribute but little to the future development of the world's knowledge. This dwarfing of mental power is necessarily experienced in every grade of teacher, starting with the university and ending with the lowest primary school or *vice versa*.

What is naturally to be expected from the conditions just given is conclusively corroborated when we note how seldom an article from a southern scholar appears in the leading journals that are devoted to the propagation of the arts and sciences, and when we observe how seldom a southern writer is quoted by a European savant.

It was a favorite saying of the great French statesman Danton that a *state must first have bread and then education*, thus making education the next necessity of life after bread.

It must be admitted by all that the southern white people are in great need of better educational facilities; and every one must also grant that it is *not* right that the south be sapped of its energies to provide wholly for the education of an inferior race, while its own white population is in such need of better education.

The educators (college presidents, etc.) of the south should recognize and make better known to the people the present conditions of the educational world (which conditions should *not* be hidden under a cloak of self-sufficiency); the statesmen of the south should make them known to the nation; and finally, *it is the duty of the nation to rectify these conditions and assume the responsibility of the education of the negro race.*

Remark

That the southern people in all the states believe in the education of the negro is shown by the fact that the negro is being educated. Still, there are many people, men of foresight and ability, who say that "education spoils good laborers." This great minority of thinkers are as a rule either unmindful or ignorant of the fact that such arguments have been in vogue regarding the education of the lower classes for

[12] See "Educational Endowments of the South," by Elizabeth M. Howe, THE POPULAR SCIENCE MONTHLY, October, 1903.

thousands of years. Still, the education of the masses has ever increased and the world thereby has gradually become more enlightened.

But with respect to the education of the colored people the great objection expressed by those who oppose this education is to be found in the "increasing peril resulting from the *higher* education of the negro."

It may be said that along the higher paths of education but few of those who have been civilized for centuries ever tread, and the higher the paths the fewer those who tread them. As would be expected, this is preeminently the case among the negro population.

The Report of the U. S. Commissioner of Education for 1899–1900, Vol. I., pp. lviii and lix of the preface, shows that 2,061 colored persons out of each 1,000,000 were enrolled in secondary and higher education for the year 1890; for the year 1907 it was 2,517 for each 1,000,000, while the general average for the whole United States had increased from 4,362 to 10,743 per 1,000,000. Thus while the attendance at the colored high school or college had increased somewhat faster than the population, it had not kept pace with the general average of the whole country, for it had fallen from 30 per cent. to 24 per cent. of the average quota.[13]

This report also shows that of all the colored pupils only one in one hundred was engaged in secondary and higher work. These figures correspond almost exactly with those given above that were compiled by Dr. Dabney from different data.

As one teacher can not handle successfully more than from forty to fifty pupils, and as all preachers and doctors should have at least some training in a high school, it is seen how entirely without foundation are the above objections regarding the higher education of the negro.

It is further to be noted that the above averages are for the whole colored population of the United States. The percentage of negro children that attend the high schools in cities, especially northern cities, is much larger than it is for the rural districts in the south. In 1900 the number of negroes in Washington, D. C., was 86,702; in Baltimore, 79,258; in Philadelphia, 62,613; in New York, 60,666, etc.

From the Report of the U. S. Commissioner of Education (1905) Vol, 2, p. 1295, it is seen that 3,349 colored students attended high schools in the territory considered in the present paper. As there are approximately seven million colored people living within this area, *there is not one colored person out of every two thousand population that ever enters the high school.*

[13] See Murphy, "The Present South," p. 61.

SHOULD PSYCHOLOGY SUPERVISE TESTIMONY?

By FABIAN FRANKLIN

PROFESSOR MÜNSTERBERG, of Harvard University, who, by his combination of scientific eminence, active interest in public questions, and rare literary skill, occupies a unique position among those who discuss large educational and social problems, recently made a plea,[1] which attracted wide attention, for the introduction of the tests of experimental psychology as a means of judging of the value of evidence given in courts of justice. To show that a deplorably large part of the evidence given in courts and elsewhere is untrustworthy for one reason or another would have been a work of supererogation; nothing is better established in the minds of all who have to deal with the subject. But, while everybody is familiar both with the phenomena of lying and loose statement, and with the fantastic tricks played by our treacherous memories, it is probable that most persons are unaware of the trouble that lurks in malobservation; and it is solely with the errors which arise from this source that Professor Münsterberg deals in the argument to which we have referred. He presents an appalling array of divergences in the outcome of ordinary observation of the same things by one hundred members of his class at Harvard; and he draws from his results the double conclusion that human observation is incomparably more fallible than is generally supposed, and that courts of justice can, and therefore ought to, test the value of the testimony of witnesses by subjecting them to the examination of the expert psychologist. If Professor Münsterberg is right in these conclusions, they are certainly deserving of the earnest attention both of psychologists and of lawyers; but, while his argument drew forth wide-spread comment, it does not seem to have been anywhere discussed with any thoroughness. And it is the purpose of this paper to show that neither the sweeping pessimism as to human reliability which would result from accepting the record given by Professor Münsterberg at its face value, nor the practical plea that he urges for the classifying of witnesses by the methods of experimental psychology, is justified upon careful examination of his argument.

To pass in review each one of the tests detailed by Professor Münsterberg, and attempt to measure the degree in which the whole array falls short of establishing the contentions which it is designed to support, would require the quotation of almost the whole of the article,

[1] *McClure's Magazine*, July, 1907.

tedious, and would demand a greater amount of space than this magazine could be expected to furnish. The nature of the objections to the article can, however, be made clear without so comprehensive and minute an examination.

Let us, in the first place, take a single one of the tests, that relating to the size of the moon:

> My next question did not refer to immediate perception, but to a memory image so vividly at every one's disposal that I assumed a right to substitute it directly for a perception. I asked my men to compare the size of the full moon to that of some object held in the hand at arm's length. I explained the question carefully, and said that they were to describe an object just large enough, when seen at arm's length, to cover the whole full moon.

The answers ranged from a carriage-wheel to a pea; and on this result Professor Münsterberg makes a number of interesting comments. "To the surprise of my readers, perhaps," he says, "it may be added that the only man who was right was the one who compared it to a pea. It is most probable that the results would not have been different if I had asked the question on a moonlight night with the full moon overhead. The substitution of the memory image for the immediate perception can hardly have impaired the correctness of the judgments. If in any court the size of a distant object were to be given by witnesses, and one man declared it as large as a pea and the second as large as a lemon-pie and the third ten feet in diameter, it would hardly be fair to form an objective judgment till the psychologist had found out what kind of a mind was producing that estimate." And elsewhere he refers to the fact that his students do not know "whether the moon is small as a pea or large as a man."

Now, this experiment, damaging as Professor Münsterberg considers it, has, in point of fact, no bearing whatever upon the perceptive powers of his students. If they understood perfectly what his question meant, and shaped their answers accordingly, those answers were the outcome of some kind of conscious mental calculation or experimentation (unless, indeed, we suppose that some of the students, for example the one with the pea, had made the explicit experiment of the obscuration of the moon by an object held at arm's length, and remembered the result). There is absolutely nothing in our direct perception of the moon to give us any idea of the angle it subtends, or of the size of an object which, held at arm's length, would "just cover it." Professor Münsterberg is, indeed, in this dilemma: either he wants to know what the intuitive feeling of a given man is as to the apparent size of the moon when he looks up at it, or he wants to know just what he explicitly declared—what object, held at arm's length, would cover it from the eye (*i. e.*, one eye). If he means the former, the intuitive feeling, each person is the final arbiter of the question—he is either lying or telling the truth; the moon either does or does not seem to

and a commentary of even greater length. Such a procedure would be him to be of the size of a plate, a cart-wheel, or what not, and there's an end. His answer can not be challenged on the score of malobservation; one may impeach either his memory or his truthfulness, but not the accuracy of his observation or even of his judgment. In other words, if the man misunderstood the question, and was really answering this other: "How large does the moon instinctively appear to you?" his answer, "as large as a carriage-wheel" or "as large as a one-cent piece," is better than any that either the psychologist or the astronomer can supply for him. If, on the other hand, the student understood the question as it was "carefully explained" by Professor Münsterberg, he absolutely deceived himself if he imagined that his "perception" of the moon's size had anything to do with the answer. We do not, by direct perception, actually estimate the angle subtended by an object, nor do we perform any equivalent operation. For any object within a small distance, we automatically make absolutely complete compensation for the diminishing angle under which it is seen as the distance increases; a plate, a silver dollar or a pea, held at arm's length, *looks* precisely as large as it does when held at the distance of a foot—we have no consciousness whatsoever that the angle it subtends is only one third as great in the former case as in the latter. The moon subtends an angle of half a degree; a large pea at arm's length does the same; a large pin's head, perhaps, does the same a foot away from the eye. But the keenest observer in the world is no more aware of these things by direct perception than is the most ill-constructed member of Professor Münsterberg's class. Our automatic compensation for diminishing angle becomes very imperfect both at great distances and in unusual circumstances—such as looking down upon the floor of the rotunda of the capitol from the gallery at the top; and for celestial objects, like the sun and the moon, it of course falls infinitely short of requirements. We make *some* compensation, though immeasurably less than what is required; and the well-known fact that people differ enormously in their feeling of the apparent size of the moon merely shows that the amount of this compensation (which, in any event, has no simple relation to the actual size and actual distance of the moon) is very different with different persons. But, strangely enough, Professor Münsterberg seems to lose sight of all these facts, and actually to regard the question of the apparent size of the moon as identical with the mathematical question of the angle that it subtends —or, what comes to the same thing, the size of an object which, held at arm's length, will "just cover" it. For while he "carefully explained" the question as meaning the latter thing, his comments relate to the former; and, in particular, in the closing remarks of his article, he speaks of his students not knowing whether "the moon is small as a pea or large as a man." By "is," he of course means "seems";

but this is a radically different question from the one specifically stated at the outset. Thus the master himself clearly slipped from one meaning to the other; and we may be quite certain that some of the answers of his students were intended for one interpretation of the question and some for the other. I feel quite sure that no member of Professor Münsterberg's class really thinks, when he looks up at the full moon, that a solid disk of the size of a carriage-wheel held up at arm's length would just suffice to shut it out from his view. He knows very well that that would shut out a considerable part of the whole sky; and the man who gave "a carriage-wheel" as his answer was almost certainly speaking of how large the moon seemed to him and not of the other question.

This example, from its peculiar nature, has required much space for its discussion; and I hasten to add that, in singling it out, I have put Professor Münsterberg's worst foot foremost. In no other of the instances is there involved, as in this one, a fundamental error. Yet a defect which, in this instance, reached the proportions of downright error is in some measure present in nearly the whole of the article. The defect I have reference to is a failure adequately to discriminate between conscious inference or conjecture, on the one hand, and the immediate dictum of sense-perception, on the other. I am perfectly aware—and it is a commonplace not only of books on logic and psychology, but also of the ordinary text-books of law—that no sharp line can be drawn between these two things. In almost every judgment, however immediately it seems to be given by the impressions made on our senses, an element of inference, conscious or unconscious, enters. Yet there is a vast difference between different cases; and, furthermore, a difference which is distinctly recognized by the wayfaring man. Professor Münsterberg begins his article by citing contradictions of testimony as to whether a road was dry or muddy and as to whether a man had a beard or not; but the staple of his article relates to estimates of the number of spots irregularly scattered on a sheet of cardboard, the rapidity with which a pointer moves around a circular dial, the interval of time between two clicks, and the like. Nowhere does he intimate that there is any vital difference between questions like these and questions of the simpler kind with which he starts out. But when a man is asked how many people he sees in a hall or how fast a train is moving, he knows perfectly well that the validity of his answer is of a wholly different nature from that which attaches to his statement as to whether the road in front of him is wet or dry, or whether a man he is looking at has or has not a beard. In the former cases, he is guessing or consciously estimating, and *knows* he is guessing or consciously estimating; but when he says that the road in front of him is wet or that the man he is looking at has a beard, he is making an assertion in which he places implicit reliance as the direct result of the

evidence of his senses. Most of the examples dwelt upon by Professor Münsterberg are simply proofs of the want of skill of his students—and of most persons—in making certain kinds of *numerical estimates*. This is interesting, and even important; but it has no such range of bearing as Professor Münsterberg seems to impute to it. And unfortunately in the only instances in which the verdict called for turned on an immediate sense-perception, the subject-matter chosen was of such a character as greatly to reduce the significance of the result. To ask whether a bit of blue paper or a bit of gray paper is the darker is to ask a technical question; the plain man simply can not put himself into the proper attitude of mind to dissociate the question of color from that of illumination, and the most natural conclusion from the failure of a number of Professor Münsterberg's students to answer the question correctly is that they had not succeeded in training themselves to that special task. The other case of direct perception is open to a similar objection. Professor Münsterberg "asked the class to describe the sound they would hear and to say from what source it came. The sound which I produced was the tone of a large tuning-fork, which I struck with a little hammer below the desk, invisibly to the students. Among the hundred students whose papers I examined for this record were exactly two who recognized it as a tuning-fork tone. All the other judgments took it for a bell, or an organ-pipe, or a muffled gong, or a brazen instrument, or a horn, or a 'cello string, or a violin, and so on. Or they compared it with as different noises as the growl of a lion, a steam whistle, a fog-horn, a fly-wheel, a human song, and what not." What does this show but that to the habitual thoughts of a great majority of the men the tuning-fork is highly unfamiliar? Otherwise nothing but diabolical perversity could have caused 98 out of 100 of the men to declare that some other instrument had produced the sound. When driven to a guess as to what some highly unfamiliar object is whose existence is announced to one of our senses, we do the best we can under the circumstances; but this is something quite different from what we habitually do under ordinary circumstances. I know of a teacher who, whenever his entire class did phenomenally badly in answering a particular examination question, inferred not that the class was stupid, but that the question was an unfair one.

While, then, nothing can be more certain than that great dangers lurk in the possibilities of malobservation, I think I have shown that the case of the average man is by no means as bad as an uncritical acceptance of the specific charges against him so formidably presented by Professor Münsterberg would lead one to believe. One of them falls down completely; most of the others relate to matters that are universally recognized to be matters of estimate or conjecture, and yet are used by Professor Münsterberg as though bearing with full force on the question of the reliability of ordinary simple observation; and even

the two remaining ones have peculiarities which greatly restrict their significance. Indeed, a moment's reflection would be sufficient to convince one that things are not as bad as they look through the professional glasses of Professor Münsterberg. If our immediate perception of the things around us, or even our judgment of times, distances, velocities, etc., were as desperately deficient as the whole tenor of Professor Münsterberg's article implies, the world could not be carried on as it is. Business transactions take place every day by the hundred million which turn on the unhesitating recognition of a rarely seen face, and the number of cases of mistaken identity is infinitesimal in comparison; we cross in front of trolley-cars and automobiles and bicycles millions of times just near enough to escape being run over, to once that we actually get run over. To translate that fine judgment of time and distance which brings us safely across Broadway into terms of feet and seconds is a task that most of us perform extremely ill; but this is a particular matter affecting the value of testimony of a special kind, and not touching the general reliability of human observation. This latter is itself undoubtedly highly impeachable; but Professor Münsterberg's tests add little, if anything, to the impeachment.

But there is another side to Professor Münsterberg's article. It is designed not only to show how frequently observation is untrustworthy, but also to advocate a method of classification of witnesses by which the trustworthy ones may be separated from the untrustworthy. "The progress of experimental psychology," he says, "makes it an absurd incongruity that the state should devote its fullest energy to the clearing up of all the physical happenings, but should never ask the psychological expert to determine the value of that factor which becomes most influential—the mind of the witness." That an appeal to psychological experts may in certain special cases be necessary or desirable I do not at all wish to deny; but it seems very clear to me, from the evidence of Professor Münsterberg's own paper, that any attempt to introduce psychological tests as a regular part of the machinery of courts in their dealings with witnesses would be utterly futile. It is conceivable that psychological experts who combined the highest scientific attainments with the most consummate common sense, and the greatest precision of reasoning with the utmost practical caution and shrewdness, could, by subjecting a witness to a sufficiently comprehensive examination, arrive at an authoritative determination of the weight that ought to be attached to his account of the facts which he alleges to have come under his observation; but nothing short of this would suffice. The difficulties in the way are many and great; but first and foremost among them comes the distinction between a laboratory experiment and the involuntary or unregulated experience of real life. Certainly accuracy of observation, whatever other elements it turns on, turns very largely on the question of attention or interest;

and the state of the attention or interest of the observer is wholly different in the ordinary circumstances of life from what it is when the observer is being tested by the psychologist. It is entirely possible that when fifty little black squares irregularly pasted on a large sheet of white cardboard are exposed for five seconds to the gaze of *A* and *B*, *A* will make a much better guess than *B* at their number, owing to his ability to concentrate his attention or to make a swift calculation; and yet that if *A* and *B* were in a hall with fifty people in it, *B* would instinctively have a much better idea of the number of people in it than *A*, owing to a habit of being interested in the scenes of which he is a natural part and in their significance. Again *A*, fixing his attention on the end of a black pointer moving over the edge of a white dial, may be vastly better able than *B* to get that ratio of the consciously observed space to the consciously observed time which is the velocity Professor Münsterberg desired his students to measure in one of his experiments; and yet if *A* and *B* were walking casually along the street, *B* might be an incomparably more reliable witness on the question whether an automobile was or was not exceeding the legal speed limit. And this matter of the different distribution of interest in different circumstances is only one of a vast number of elements which go to making the psychologist's test highly precarious. You must catch a man "in his habit as he lives," you must follow him into all sorts of situations under all sorts of circumstances, internal and external, before you can decide what value to attach to his statement as to the facts that come into his ordinary experience of daily life. The man who may be too dull-witted to understand the psychologist's question, too lethargic to make a decent observation of what is put before him by his examiner, or too "rattled" to state correctly the result of that observation, may be a man who, as he goes about his work or chats with his fellows, misses nothing of the ordinary human occurrences that take place around him. And, on the other hand, the man of quick intelligence and keen activity who, upon demand, can bring all his faculties to bear upon a subject on which he is challenged to make a creditable report may, not only *in spite* of having this temperament, but actually *because* of it, be the very man who habitually takes extremely imperfect notice of the visible and audible things that are going on around him all the time and that have for him no significance.

Difficulties like these—I do not say insuperable difficulties, but certainly difficulties that offer enormous resistance to the investigator—are inherent in the subject. But over and above these inherent difficulties are those which attach not so much to the investigation as to the investigator. As a practical proposition, Professor Münsterberg's project must contemplate the employment of the psychological expert as an expert, strictly speaking. His report on the capacity of a witness

must be taken by court and jury on his authority; it could not be expected of the court, still less of the jury, that it should examine into the soundness of the methods which he had employed. Yet it must be plain from what has been pointed out above that, even assuming—which is a great deal—the possibility of expending the necessary amount of time and pains upon the inquiry, none but the most highly qualified expert could be safely entrusted with it. Professor Münsterberg is a man not only of the highest professional training, but of extraordinary native powers of mind; yet he not only makes a fundamental error in one instance, but in a number of others overlooks elements essential to the true bearing of the facts upon the question in hand. In addition to the points already noted, one other may be mentioned which throws perhaps an even stronger light on the pitfalls that lie on all sides. It is a curious circumstance that in none of the questions put by Professor Münsterberg to his class does he give any room (or at least any encouragement) to the simple answer, "I don't know." How many of the queer guesses he got in response to the question as to what caused the sound he made by striking the hidden tuning-fork would have been choked off by the simple and straightforward plan of telling the students to answer only in case they felt a reasonable assurance, there is no means of telling. And yet in court a truthful witness would do that very thing. If he had heard a sound the character of which he could not identify, he would so state to the court, and not say it was a bell or a church organ or a human song or what not. A man who, upon being asked to make the best guess he can, makes a very bad guess is not necessarily an unreliable witness; he may be the very man who on the witness stand would refuse to testify to things that he doesn't feel sure of, and who, when he does make a statement, may be implicitly believed. And the same remark applies, in some measure, to nearly all the tests in Professor Münsterberg's questionary. If Professor Münsterberg has laid himself open to criticism in so many points, how much less would it be possible to entrust to an every-day psychologist the decision of so delicate a question as that of the degree of reliability of each of the witnesses in a given case?

There is one very striking test, of a different character from any of the others, to which I have made no reference, and which might be pointed to as concrete proof of the correctness of the method in spite of any criticism that may be brought against it in the abstract. This is an experiment in which Professor Münsterberg, having asked his class to describe everything that he was going to do from one signal to another, did certain conspicuous things with his right hand, upon which he ostentatiously fixed his own attention, while at the same time he did a number of other things with his left hand. The result was that 18 out of 100 students were utterly unaware that he was doing

anything at all with his left hand. This of itself would not be surprising, it being a phenomenon familiar in all sorts of sleight-of-hand performances; but the striking fact was developed that of these eighteen non-observers fourteen were included among the twenty men (or thereabout)[2] who had judged a dark blue to be lighter than a certain lighter gray. "That coincidence," says Professor Münsterberg, "was of course not chance. In the case of the darkness experiment the mere idea of grayness gave to their suggestible minds the belief that the colorless gray must be darker than any color. They evidently did not judge at all from the optical impression, but entirely from their conception of gray as darkness. The coincidence, therefore, proved clearly how very quickly a little experiment such as this with a piece of blue and gray paper, which can be performed in a few seconds, can pick out for us those minds which are utterly unfit to report whether an action has been performed in their presence or not. Whatever they expect to see they do see; and if the attention is turned in one direction, they are blind and deaf and idiotic in the other." That the coincidence is not a matter of chance may be admitted as practically certain; and yet there is ample room for disputing the inference which Professor Münsterberg draws from it. He finds in it a triumphant proof of the adequacy of an extremely simple and special little test for a sweeping conclusion as to the general powers of observation of the men subjected to it. But surely there is another possible explanation. There is one thing that both the color test and the sleight-of-hand test have in common; the danger of a wrong answer in either case may lie chiefly in a failure on the part of the student to grasp firmly and clearly the exact and full import of the question. The man that is alert and keen-witted and intent in his attitude toward the test will both know exactly what is meant by the question of the relative brightness of the two colored papers and be on his guard as to the possibility of a trick (for that is what it is) in the attempt to concentrate his attention upon the spectacular doings of the right hand. The man less keyed up to the requirements of the tests will be in danger both of failing to make the requisite discrimination in the question of brightness and of falling into the trap laid for him in the sleight-of-hand performance. Professor Münsterberg may have (but he certainly does not mention it) confirmatory evidence of the conclusion he draws from the coincidence; but on the face of it that coincidence may quite as plausibly be accounted for in the manner I have indicated as it is by the supposition that an inability to determine which of two differently colored paper squares is the darker carries with it a high probability that the observer is "utterly unfit to report whether an action has been performed in his presence or not." The common observation of every-day life is of a radically different character from what is

[2] "About one fifth of the men" is Professor Münsterberg's statement.

involved in either of these two associated tests; and the man who distinguishes himself in both may, in ordinary life, with his senses and his intellect in their normal state, be a far worse observer and a far worse reporter of the things going on around him than the man who is either too indifferent or too slow-witted to bring his mental and physical faculties to bear adequately upon the artificial test.

It is far from being the purpose of this paper to cast discredit on the methods of experimental psychology. On the contrary, the writer feels that the advance made by that science has been among the most interesting and important of the scientific developments of the past three decades. In Professor Münsterberg's succeeding paper, "The Third Degree," for example, are to be found a number of illustrations of the remarkable results that have been obtained by the methods of experimental psychology. The account of them given by the distinguished professor with that skill and attractiveness of which he is a rare master, while as interesting as a romance, is full of convincing force. The questions there discussed have at once intense theoretical interest and great practical importance; but there is this difference between them and the questions at issue in the paper I have been criticizing: In worming out of a suspect, or a hysterical patient, the secret he is endeavoring to guard, the thing under examination by the expert is highly definite. It is something in the actual contents of the subject's mind or in his emotional susceptibility on certain definite matters. The study of his reaction-times, association-times, etc., has been shown to furnish astonishingly definite information on these specific things. The point made in the present paper is simply that no such case has been made out in the much broader, looser, more varied and more intangible region covered by the question of the trustworthiness of every-day human observation; that the indictment brought against such observation, not so much by the exact letter as by the whole tenor of Professor Münsterberg's article, is not sustained by his instances; and finally that, so far as regards the discrimination of trustworthy from untrustworthy witnesses (truthfulness aside) as to the affairs of ordinary life, the investigation by expert psychologists, in order to be entitled to authority, would have to be vastly more comprehensive and vastly more able than there is any practical possibility of commanding. That there are special classes of cases in which the expert's investigation of a witness would be of value is certain, but the scope of his usefulness must be regarded as severely limited. So far as the ordinary run of things is concerned, the present homely procedure, imperfect as it is, is to be preferred to a system in which, over and above the question of the trustworthiness of witnesses, there would be injected into every case of importance the further and at least equally puzzling question of the trustworthiness of the tests employed by the psychological expert.

THE PROGRESS OF SCIENCE

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING AND THE STATE UNIVERSITIES

SCIENCE and higher education in this country have been placed under further obligation to Mr. Andrew Carnegie for his generous intentions in adding $7,000,000 to the endowments of the two institutions that bear his name. The Carnegie Institution of Washington has been given $2,000,000 without special conditions, and the Carnegie Foundation for the Advancement of Teaching has been given $5,000,000 in order that its system of retiring allowances may be extended to state universities.

If the cost of steel had not been excessive through the tariff and the cost of kerosene had not been excessive through monopoly, every state in the union could have afforded to endow institutions for scientific research equaling the Carnegie Institution of Washington, and universities equaling the University of Chicago. But they would not have done so; nor would the gains of the people have been saved and combined to carry forward the construction of railways and other enterprises which the capitalistic system has accomplished. It is one of the anomalies of our complicated civilization that the tariff and the trusts, apparently for the benefit of capitalism, are long steps in the direction of state socialism, whereas the universities supported by the states are the nurseries of democratic individualism.

These remarks are suggested by the paternalistic and centralistic character of the pension system now extended to the state universities. Whether this extension is a benefit or an injury to these institutions is a question not at all easy to answer. It was urged by a committee of the presidents forming the National Association of State Universities, whose chief argument was that it is unlikely that the states will provide pensions for professors, as this might raise the question of pensions for all public officers, and that the state universities would thus be at a great disadvantage as compared with private institutions. President Pritchett of the foundation, in his report on the subject printed last year, argued that the desirability of the pension system and its adoption by the private institution would force the states to provide it for their universities.

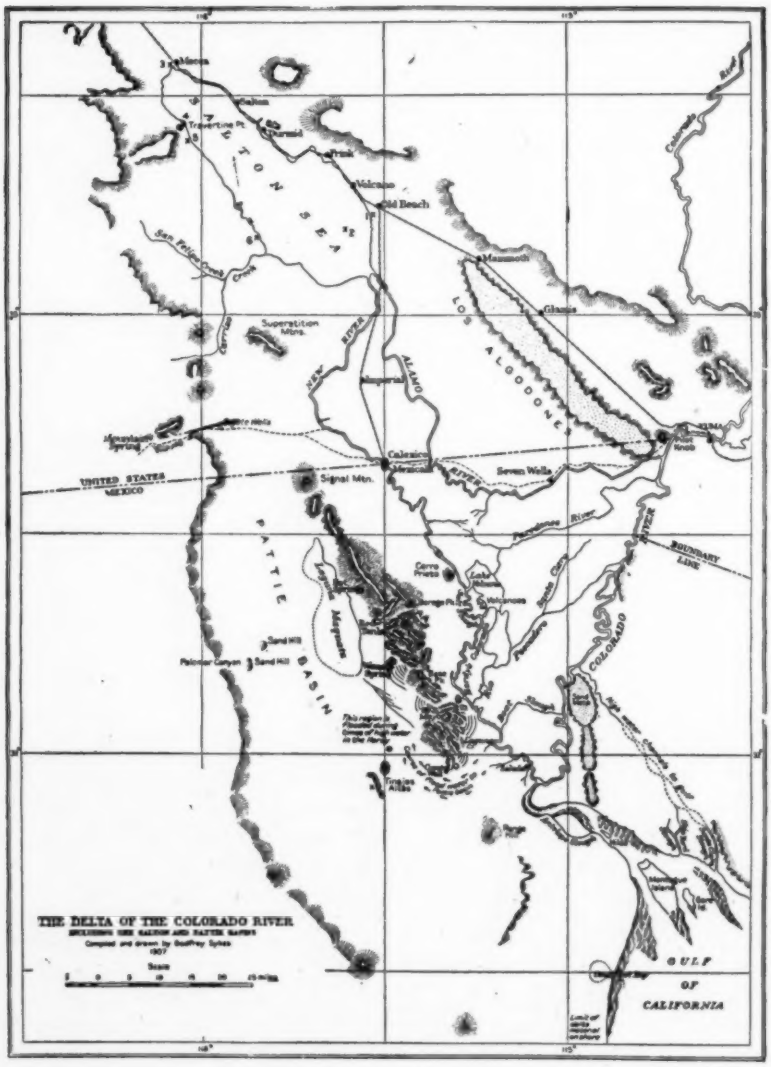
But the desirability of a uniform and universal pension scheme for professors is at least open to question. If one university pays a salary of $3,000, and another pays $2,500 and provides an annuity the annual cost of which is $500, the charge to the institution and to society is the same. In which is the position of the professor preferable? Those who insure themselves for the benefit of wife and children are better citizens than those who stint their families in order to buy annuities for their own old age; but it seems that college professors are to be compelled to join the latter class. They must sacrifice a certain amount of freedom in accepting annuities in place of salary and are put into a caste that they can not leave without serious money loss.

On the other hand, it may be argued that the scholar should be relieved from all financial responsibility, in order that he may be free to do his work. It is also claimed that it is an advantage for an institution to be able to replace its older professors with younger men. The introduction of the system is of financial advantage to

men already in the service of institutions that did not have pensions, as tney get an annuity for which they have not paid. And, of course, Mr. Carnegie's liberal gift provides additional income to institutions for higher education. Hence it is favored by university presidents and from this point of view is not unwelcome to professors. But the present writer regards the increase in the course of ten years of the annual appropriations for ten of the western universities from $1,689,000 to $4,577,000—equivalent to an increase in endowment of some $75,000,000—as immeasurably more significant than the extension of Mr. Carnegie's pension scheme to these universities.

THE VEGETATION OF THE SALTON SEA

We have published several articles on the scientific and engineering problems arising from the overflow of the



ALKALINE SLOPE ON THE SHORE OF SALTON SEA.

Colorado River into the Salton Basin. It will be remembered that in the autumn of 1904 an irrigation ditch was eroded into a stream that carried an enormous amount of water from the river into the sink—at its lowest level 280 feet below that of the sea—and formed a lake some five hundred square miles in extent, which threatened to extend and submerge a flourishing district. After repeated failures and the expenditure of several million dollars, the overflow was checked early in 1907.

The submergence of this area and its drying up have caused and will cause changes in the vegetation which may throw light on the distribution of plants, and the Department of Botanical Research of the Carnegie Institution, under the direction of Dr. D. T. MacDougal, with its Desert Laboratory at Tucson, Arizona, was in a position to take up this problem. It has been extended to the Pattie Basin, into which flood water escapes nearly every year. The general plan of the work is described in the last Year Book of the institution, from which the accom-

DESERT WASH OCCUPIED BY AN ARM OF THE SALTON SEA.

panying map and illustrations are taken.

Early last year an expedition was organized and embarked in a sailboat, designed for the circumnavigation of the Salton Sea and an examination of its contacts with the adjacent desert vegetation. Six stations were selected from which under varying conditions the succession of vegetation will be studied as the water recedes. The maximum depth of the water is 84 feet, and it is expected that most of it will evaporate in about ten years. Its width is from five to twenty-five miles, and each year new stretches of beach will become available for occupation by plants. The level of the lake fell about one foot by June 1, and two or three feet six months later. At that time the strip of saline shore left bare had not been occupied by plants.

The Desert Laboratory has under way various other studies in acclimatization and the influence of physical features on vegetation. Thus four stations have been chosen at elevations, respectively, of 2,200, 2,700, 6,100 and 8,000 feet, and transplantations cause marked structural changes in the plants. Attention is given to the determination of whether these changes are transmitted and persist in localities other than the one in which they originated.

JOHN SAMUEL BUDGETT

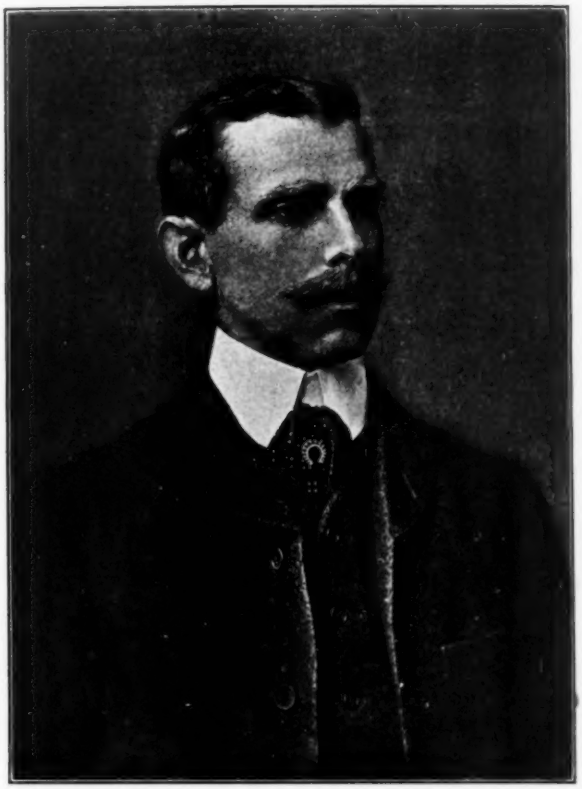
It is becoming that honor should be paid to those who sacrifice their lives for science. One of the strongest props of militarism is the instinctive respect commanded by the soldier who is ready to die for his country. It should be widely known that in laboratories and in the field men of science are quietly at work with dangerous organisms, with poisons and explosives, exposed to disease, accepting risks for the advancement of science and the welfare of man greater than those to which the soldier is liable.

A fitting tribute to one of this company of scientific martyrs has been paid in the publication of a volume in memory of John Samuel Budgett, who died from fever contracted in several visits to the jungles of South America and Africa. He had gone in search of zoological material and especially to study the development of *Polypterus*, which is one of the two surviving forms of the great group of fishes that flourished in the Paleozoic and Mesozoic periods.

The memorial volume, which is beautifully printed by the Cambridge University Press, contains a biographical sketch of Budgett by Professor A. E. Shipley, a collection of his zoological papers and several papers by Mr. Richard Assheton and others, consisting of the completion of the work begun by Budgett on the material that he had collected.

Budgett was born at Bristol in 1872. Like nearly all those who have done good work in natural history, he showed early his interests and aptitudes. As is so often the case, his father was keenly interested and naturalists visited his house; he was irregular in his school attendance and did not do very well at examinations. Before he completed his course at Cambridge, he went with Mr. Graham Kerr to the Gran Chaco of Paraguay in search of *Lepidosiren*. The expedition was brilliantly successful and brought back a large supply of specimens of this practically unknown lungfish, including eggs and larvæ in all stages of development. Budgett's first paper was an account of the batrachians of the Paraguayan Chaco, published in 1898.

After obtaining his degree, he took up with dauntless courage the search in Africa for *Polypterus*, about whose habits and development nothing was known, but whose primitive condition might be expected to throw light on the origin and relationship of fishes. In search of these fishes Budgett visited the Gambia, the Victoria Nile and the Niger, undismayed by innumerable difficulties including malaria



JOHN SAMUEL BUDGETT.

and blackwater fever. He obtained a vast amount of important scientific information in regard to *Polypterus* and in other directions, and in his last expedition accomplished the artificial fertilizing of the eggs and the study of their development. But he sacrificed his life to attain this end, and died before completing his work at the age of thirty-one.

SCIENTIFIC ITEMS

WE regret to record the deaths of Dr. William Ashbrook Kellerman, professor of botany at the Ohio State University, from tropical fever while engaged in the study of the flora of Guatemala; of Dr. Edouard Zeller, the eminent historian of philosophy, at the age of ninety-four years; of Dr. William Edward Wilson, F.R.S., who had carried on important research in his astronomical observatory and astrophysical laboratory on his estate in Westmeath, Ireland; of Dr. H. C. Sorby, F.R.S., known for his researches on the microscopical structure of rocks and metals; of Sir John Eliot, F.R.S., eminent for his services to meteorology; of Dr. A. Howitt, author of important anthropological works on the natives of Australia; of Sir Denzil Ibbetson, known for his contributions to the ethnology of India; of Sir Alfred Cooper, a distinguished London surgeon, and of Professor Laurent, professor of mathematical analysis at Paris.

MAJOR GENERAL A. W. GREELY, eminent for his arctic explorations and his services to meteorology, having reached the age of sixty-four years on

March 27, was transferred to the retired list in accordance with law.—The Turin Academy of Science has conferred the Bressa prize of about $2,000 on Dr. Ernest Rutherford, professor of physics at Victoria University, Manchester.—Dr. W. M. Davis, Sturgis-Hooper professor of geology, has been selected by the German government as Harvard visiting professor at the University of Berlin for the academic year 1908–9.—President Eliot, of Harvard University, delivered in April six lectures at Northwestern University on the Norman W. Harris Foundation. His general subject was "University Administration."

PROVISION will be made by the Canadian government in the estimates for the coming financial year for a grant of $25,000 by the Dominion parliament towards the expenses of the visit of the British Association to Winnipeg. The city of Winnipeg proposes to make a grant of $5,000. The week of the meeting will probably be from August 25 to September 1, 1909. Dr. J. J. Thomson, Cavendish professor of experimental physics at Cambridge, will preside.

IN the bill making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1909, and just introduced into the House, the total sum appropriated is $11,431,346. Of this amount the following sums are appropriated to what may be termed the scientific bureaus and offices of the department: Forest Service, $3,796,200; Weather Bureau, $1,662,260; Bureau of Plant Industry, $1,331,076; Bureau of Animal Industry, $1,330,860; Bureau of Chemistry, $791,720; Bureau of Entomology, $434,960; Office of Experiment Stations, $230,620; Bureau of Statistics, $221,440; Bureau of Soils, $204,700; Office of Public Roads, $87,390; Bureau of Biological Survey, $62,000, making a total of $10,254,226.

THE Kentucky legislature, recently adjourned, changed the name of the College of Agriculture and the Mechanic Arts to the State University and appropriated to it $200,000 in addition to what it has already been receiving; $30,000 of this amount is to be annual. At the same time it appropriated $150,000 each to the two new State Normal Schools.—Plans for two new buildings have been accepted by the board of trustees of the University of Illinois. One is a physics laboratory, to cost $250,000, the other an extension of the natural history building, to cost $150,000.